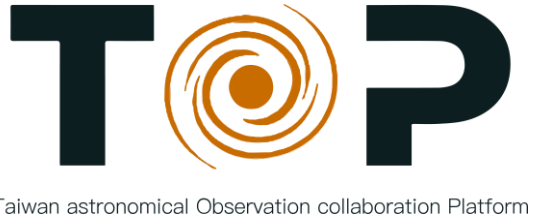
2025.02.21 A&A Journal Club

How I became an Amateur Planet Hunter



Yen-Hsing (Julius) Lin (UCSD)

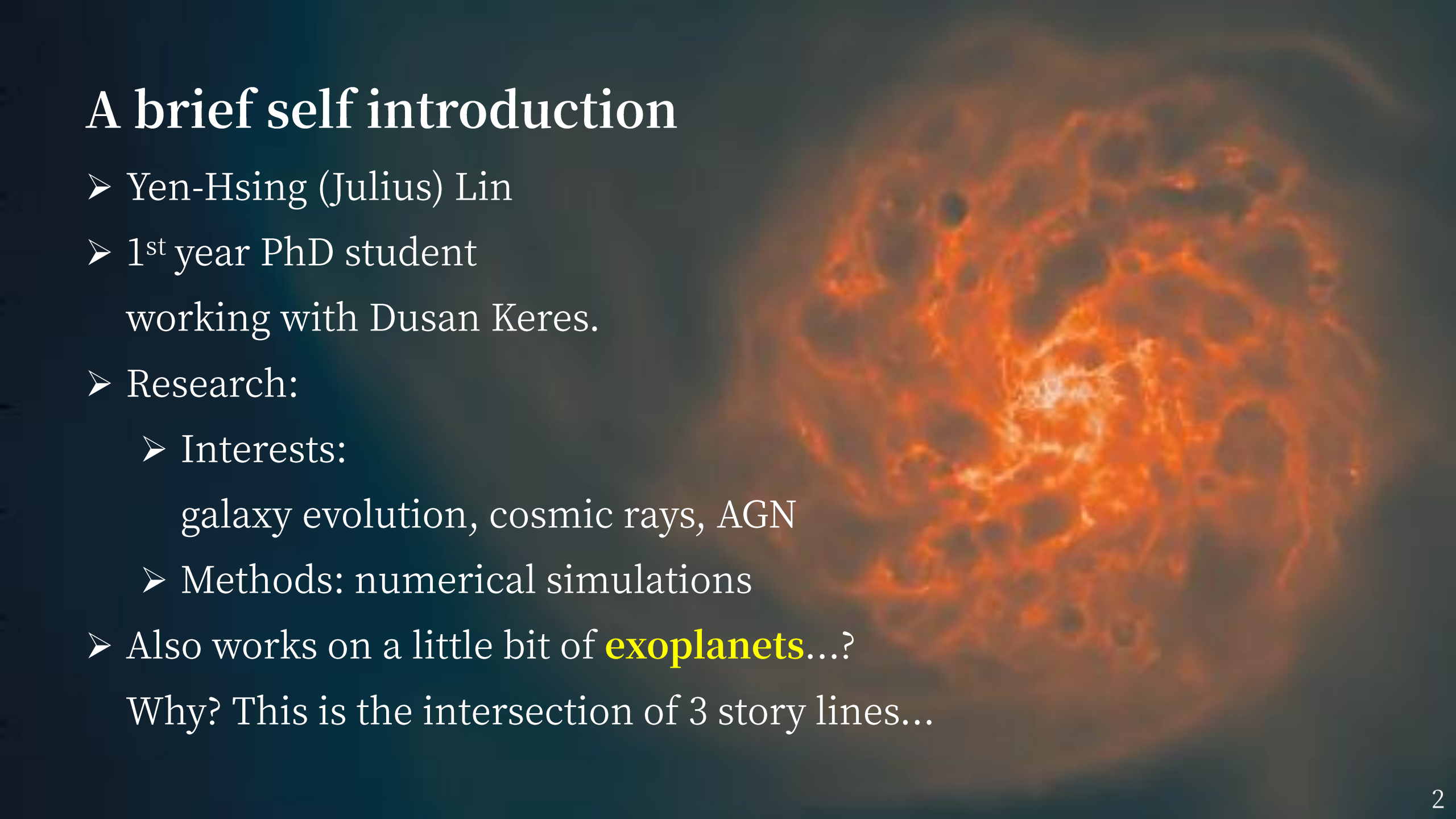
A brief self introduction

- Yen-Hsing (Julius) Lin
- 1st year PhD student

  working with Dusan Keres.
- Research:
  - Interests:

    galaxy evolution, cosmic rays, AGN
  - Methods: numerical simulations
- Also works on a little bit of **exoplanets**…?

  Why? This is the intersection of 3 story lines…



Story 01:

My Journey to Amateur Astronomy

My Journey to amateur astronomy

- Early fascination with physics and astronomy.
- High school: Traded stars for sports.

  I was in table tennis club instead of astronomy.
- College:

  I can finally join the astronomy club!

  → One major decision that made me who I am right now.

Key techniques learned:

Assemble and operate small telescopes.

End-to-end knowledge on optical observation.

I was one of the few students in the IoA who had both:

- Professional astrophysics training
- Practical experience in amateur astronomy.

Wen-Hsin

Senior master student

Want to get a free trip for star gazing and teach some high school students astronomy?

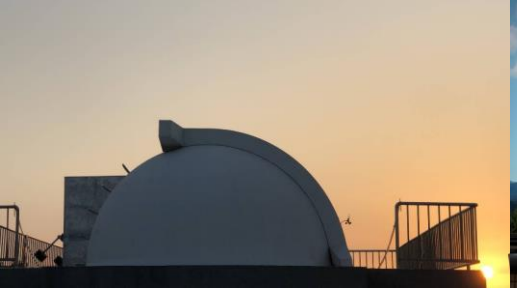
YES

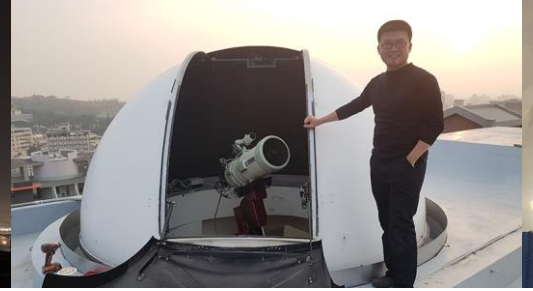
Me

1st year master student

Story 02:

The TOP Project



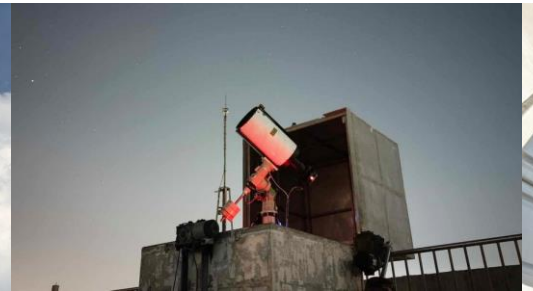
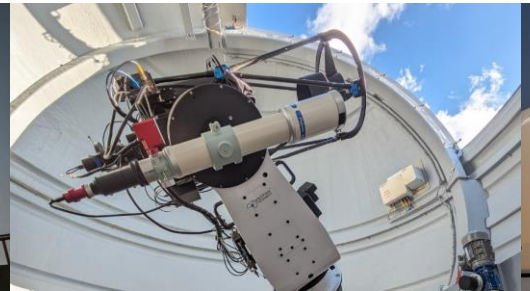

Challenges / opportunities for urban observatories

There are many observatories in Taiwan, but not all of them are fully utilized.

limited expertise, human resources, and urban light pollution

Taiwan astronomical Observation collaboration Platform (**TOP**)

help unlock the full potential of these observatories.

How to solve the problem?

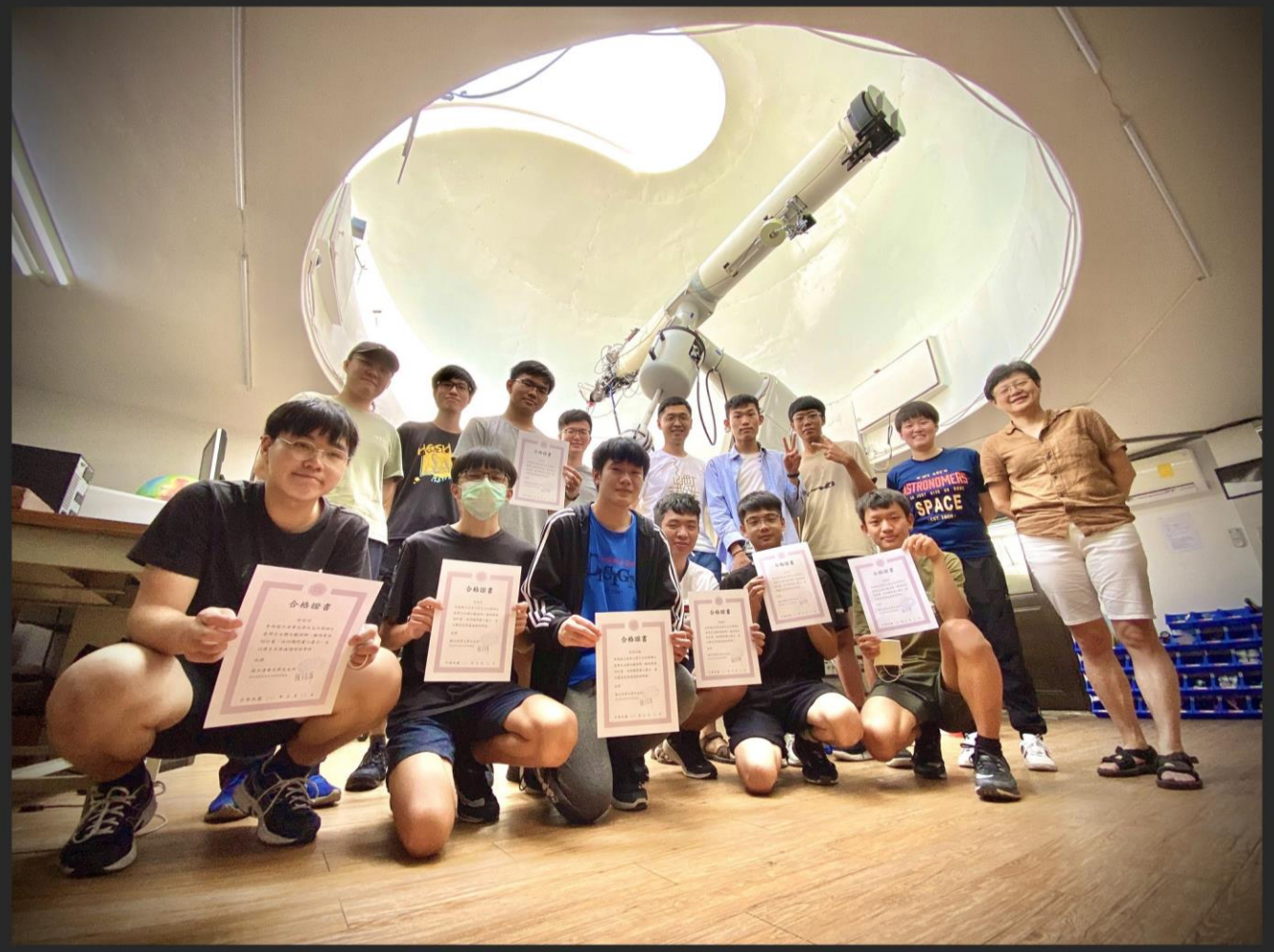
Direction 1

Provide knowledge / build a community

among current observatory operators/owners.

Direction 2

Train passionate high school students to become future observers.



Wen-Hsin Chen

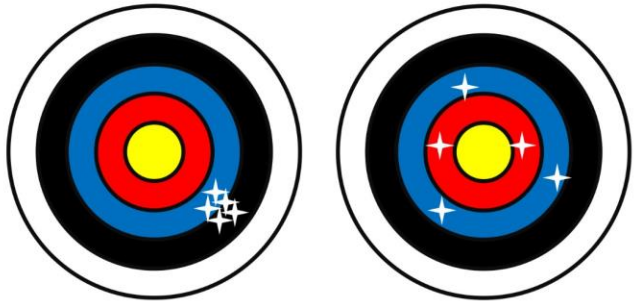
2022 Summer Camp

- We worked with astronomy club of a local high school.
- Six days long, from
  - Physical principles
  - Planning observations
  - Conduct observations
  - Calibration / analysis
  - Presentation
- End-to-end training

Recap

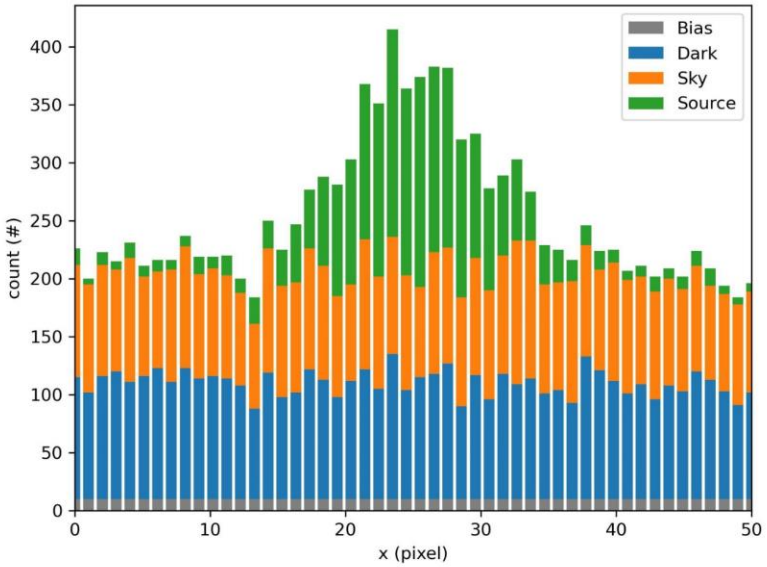
前情回顧

- 天文攝影：紀錄天體資訊
- 凡是測量，就必然伴隨：
  - 偏差（Bias）
  - 不確定性（Uncertainty）
- 偏差可以被**校正**，
  不確定性則無法移除。
- 影像處理：校正偏差，盡可能真實地還原影像中天體的資訊。



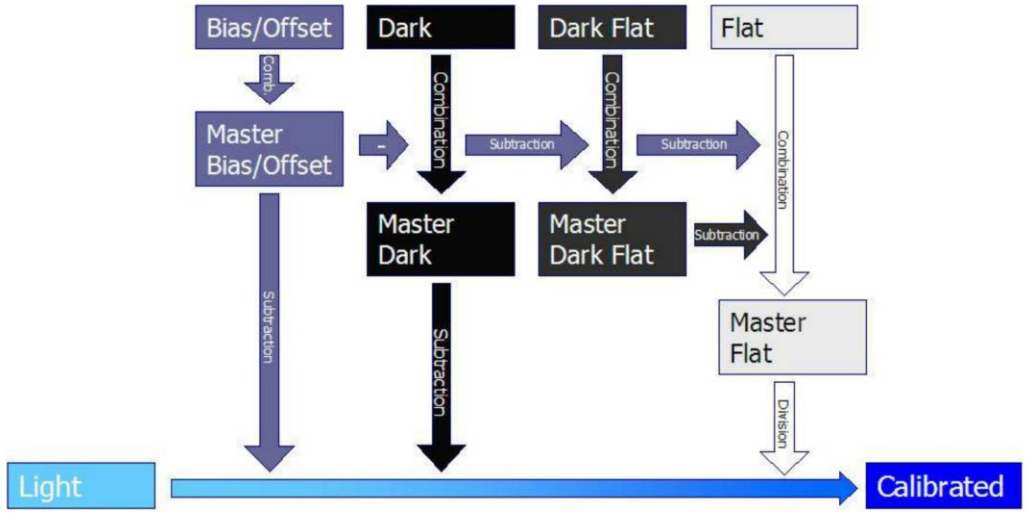
高精度，低準度
High Precision, Low Accuracy.

低精度，高準度
Low Precision, High Accuracy.



問題：如何把天體的訊號分離出來？

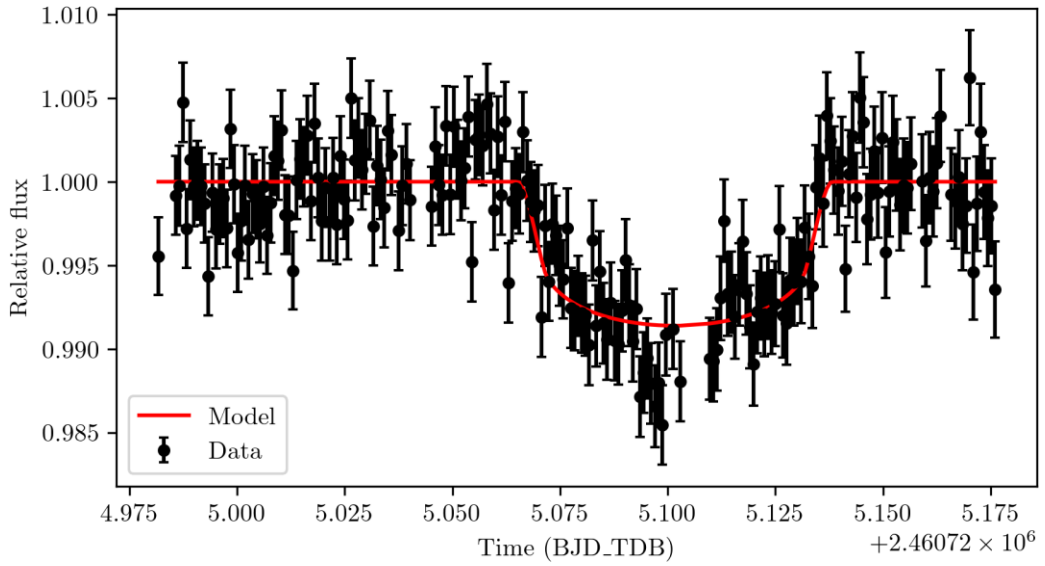
完整影像校正流程



Question: what should be their final project?

We want them to utilize all the knowledge they learn during the camp.

Astrophotography | Art



Exoplanets | Science

Wen-Hsin

Senior master student

You can observe exoplanet transits with small (~10 inches) telescopes!?

YES

Me

1st year master student

Story 03:

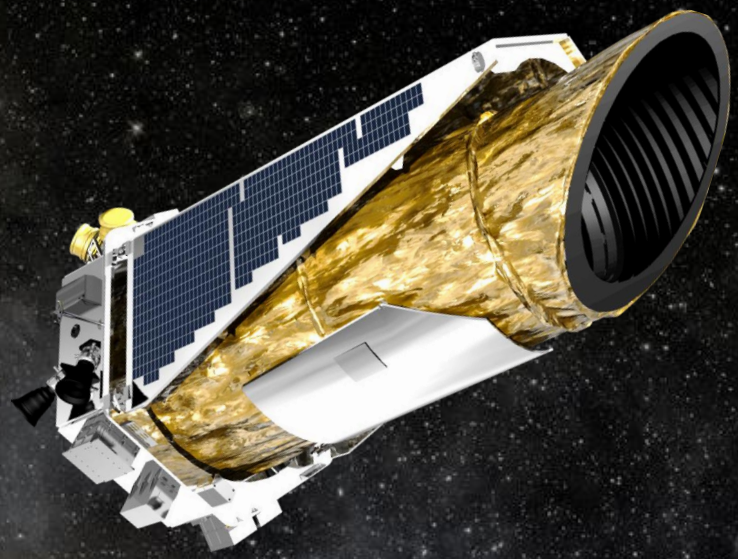
The ExoClock Project

Exoplanets!

- One of the hot topic in astrophysics.

  Connecting to the big questions:
  - Where do we come from?
  - Are we alone?
- Since 1995, we have found ~6000 exoplanets.

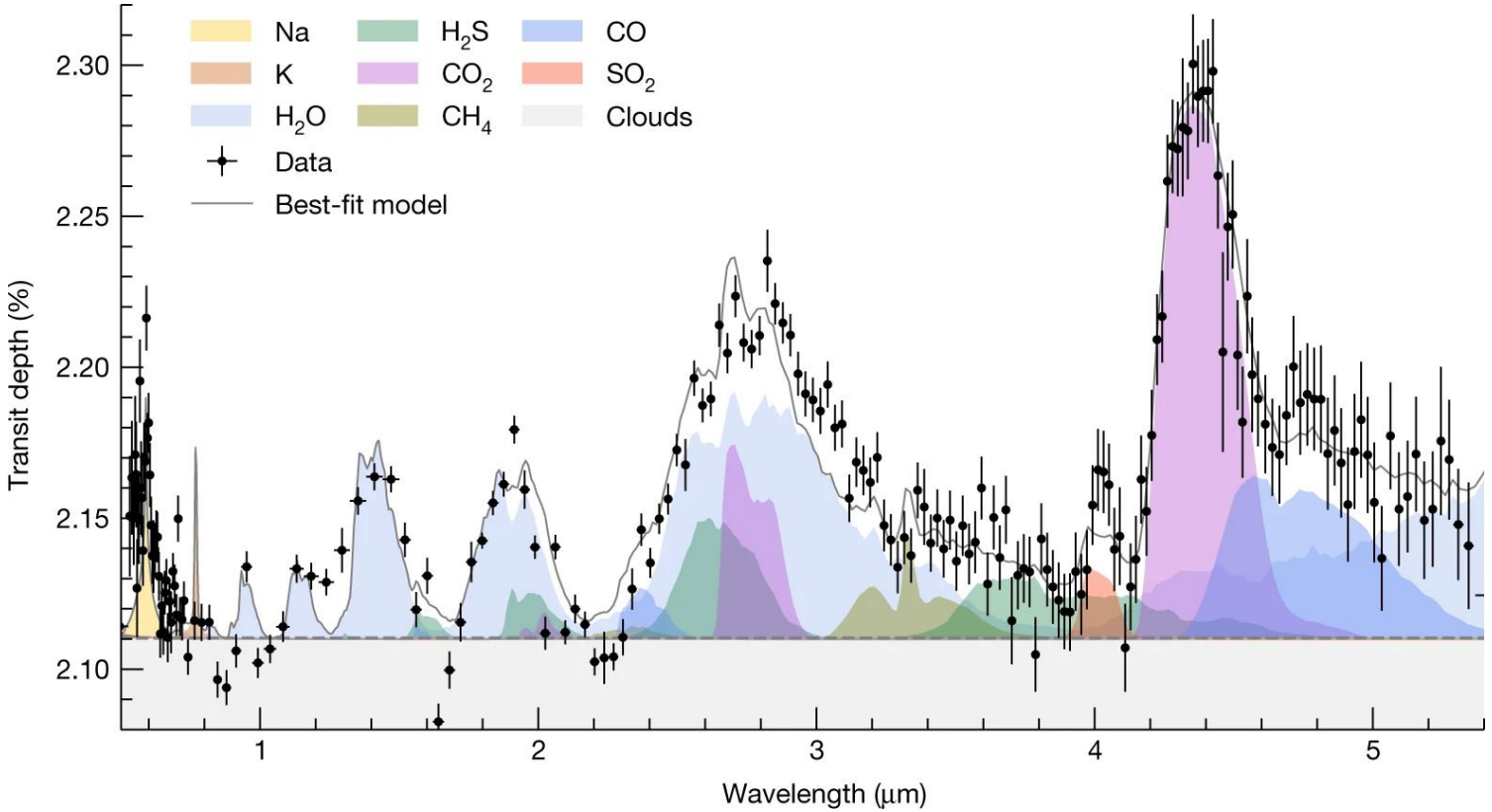
  Most are found by the **transit** method.
  - Kepler/K2 mission
  - TESS mission

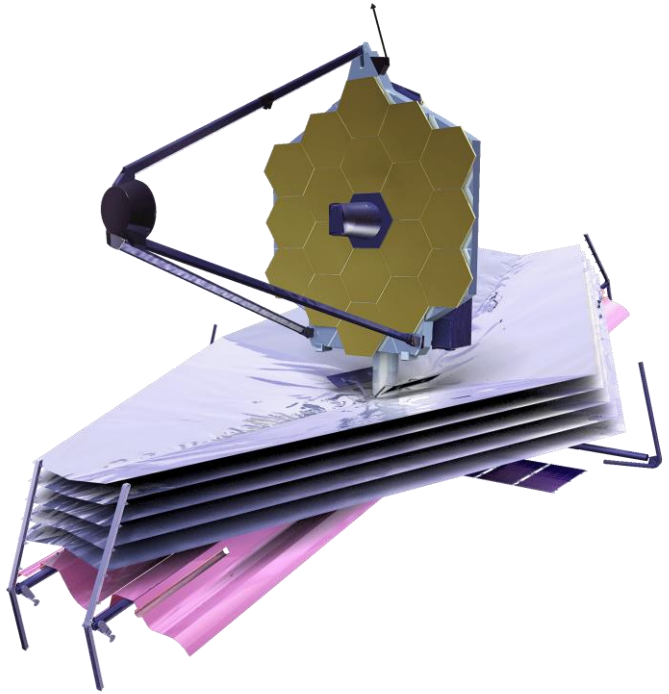


NASA/Ames/JPL-Caltech

Transmission spectroscopy

Spectra during transit → exoplanet atmosphere





Ariel mission

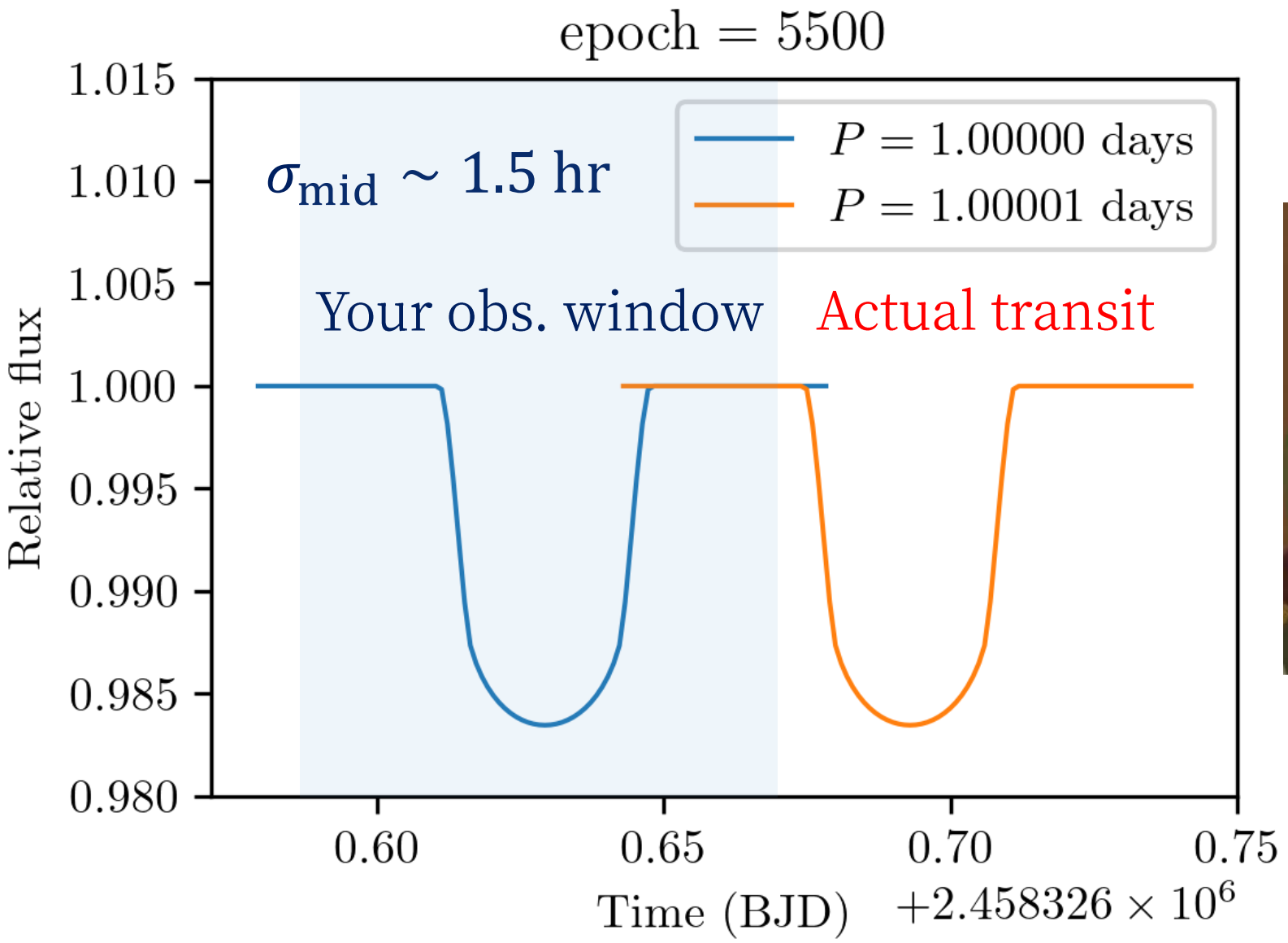
- ESA's exoplanet atmosphere survey telescope.
- To be launch to Sun-Earth L2 in 2029 along with Comet Interceptor.
- NIR – MIR transmission spectroscopy on >**1000** exoplanets in 4 years. Massive survey!
- But there is a challenge: the ephemeris!

Challenge: Ephemeris!

Imagine a planet had a transit with duration 1 hr at 2010.01.01 00:00.

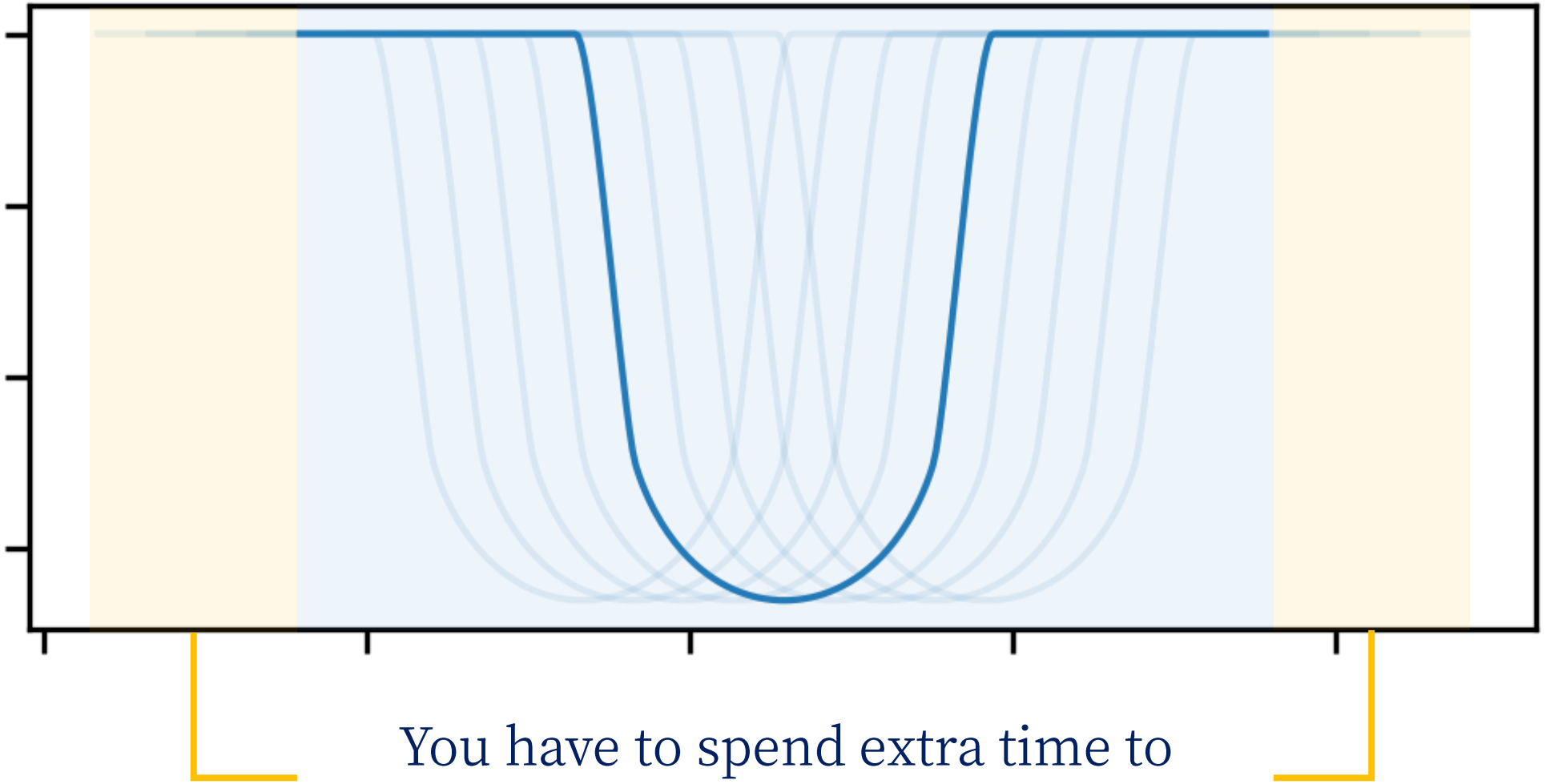
The period is measured to be 1 day ± 1 second.

If you want to observe it on 2025.01.01, what is the transit time uncertainty?


epoch = 5500
$\sigma_{\mathrm{mid}} \sim 1.5$ hr
$P = 1.00000$ days
$P = 1.00001$ days
Your obs. window
Actual transit
Relative flux
1.015
1.010
1.005
1.000
0.995
0.990
0.985
0.980
0.60
0.65
0.70
0.75
Time (BJD)
$+2.458326 \times 10^6$


Years of academy training wasted!

The time you actually need



You have to spend extra time to avoid missing the transit

The ExoClock Project

- Open science project under Ariel / ESA.
- Maintain good ephemeris for Ariel scheduling.
- Perform follow up observations on Ariel targets using telescopes from both professional and amateur community.
- Process:
  - ExoClock: provide customized schedule for each contributor.
  - Contributors: observe, analyze, and upload lightcurves.
  - ExoClock: collect and analyze thousands of data and publish.

My Schedule

Showing all the planets that are accessible by your telescopes in the next 24 hours.
For a more generic scheduler visit the ExoWorlds Spies Scheduler

Equipment information

NTHU Observatory - Showa 10" - ASI6200MM Pro

Latitude: 24.794180844238777°, Longitude: 120.99191026682676°, Telescope aperture: 10.0"
Effective telescope aperture (based on 1 verified observations): 10.0"

Observation priority:
ALERT
HIGH
MEDIUM
LOW

Observation is suggested to cover at least 1 hour before and after the transit event.

Planet & ExoClock status	Details	Observing times [UTC+8.0] and target position				
		1h Before Ingress	Transit Start	Mid Transit	Transit End	1h After Egress
K2-31b (HIGH) Min. aperture: 7.7" Total Observations (Recent): 14 (1) O-C: -0.06 ± 0.97 minutes	RA: 16:21:45.7780 hours (J2000) DEC: -23:32:52.289 degrees (J2000) Mag_R: 10.292 mag $Depth_R$: 8.26 mmag Duration: 0.98 hours	2024/05/26 20:23 Alt: 19° Azi: 128° (SE)	2024/05/26 21:23 Alt: 29° Azi: 139° (SE)	2024/05/26 21:52 Alt: 33° Azi: 145° (SE)	2024/05/26 22:22 Alt: 36° Azi: 152° (SE)	2024/05/26 23:22 Alt: 41° Azi: 169° (S)

Max counts increase during observation: **R:15% V:32%**
Moon illumination: **89.8%**, Moon distance: **34.6°**

Transit timing uncertainty.

Target brightness in R-band.

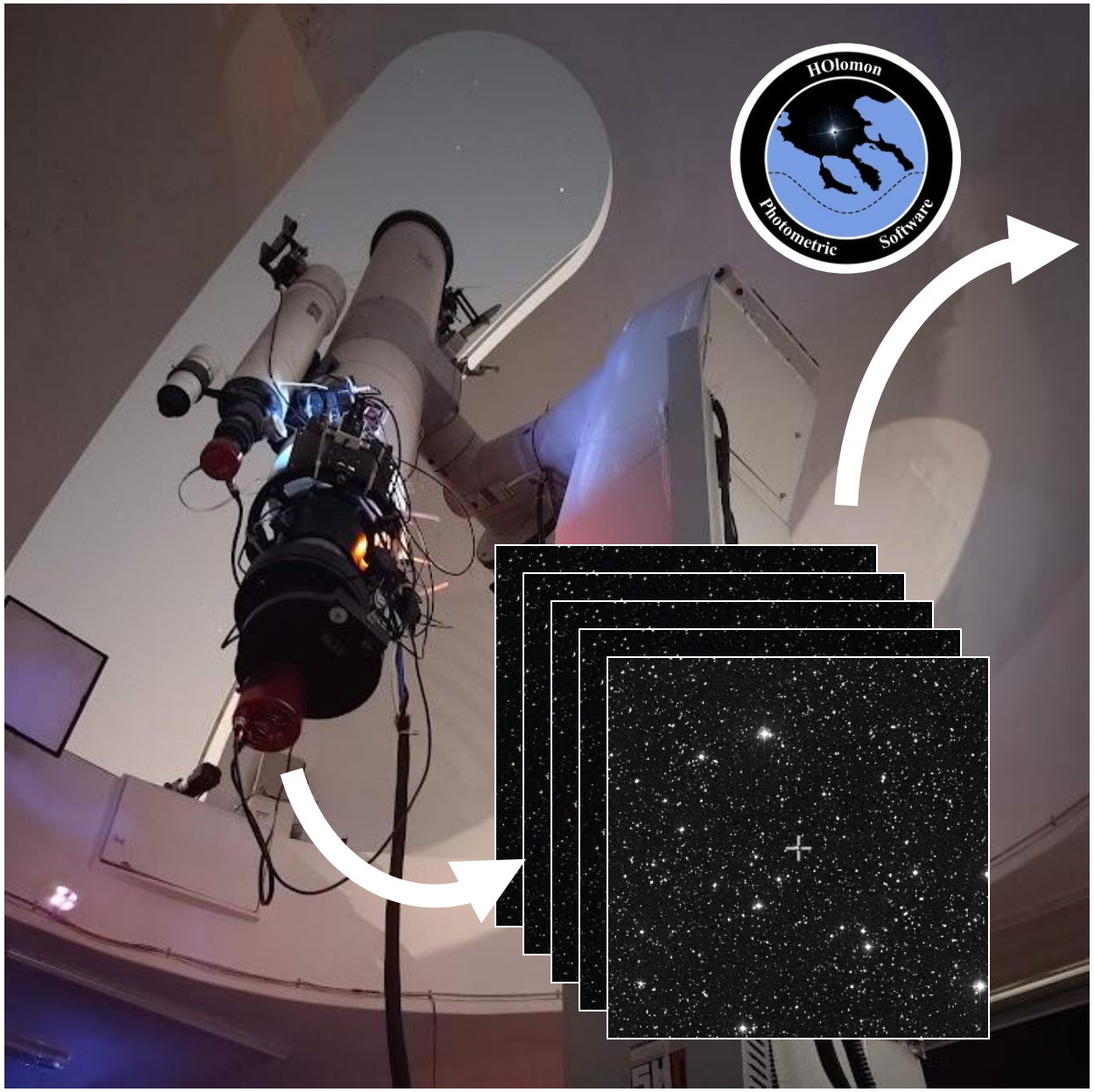
Transit depth in R-band.

Transit duration for this event.

Words in red means the altitude is too low or the sky isn't dark.

TOI-3819b (LOW) Min. aperture: 13.43" Total Observations (Recent): 10 (3) O-C: 0.59 ± 1.05 minutes	RA: 08:07:27.1889 hours (J2000) DEC: +29:23:19.472 degrees (J2000) Mag_R: 12.441 mag $Depth_R$: 6.35 mmag Duration: 2.78 hours	2025/02/22 19:44 Alt: 61° Azi: 71° (E) HA: 21.86h	2025/02/22 20:44 Alt: 74° Azi: 65° (NE) HA: 22.86h	2025/02/22 22:08 Alt: 83° Azi: 331° (NW) HA: 0.25h	2025/02/22 23:31 Alt: 67° Azi: 290° (W) HA: 1.65h	2025/02/23 00:31 Alt: 54° Azi: 288° (W) HA: 2.65h	Meridian crossing at: 2025/02/22 21:50 Max counts increase during observation: **R:1% V:3%** Moon illumination: **32.2%**, Moon distance: **147.2°**		
HAT-P-30b (LOW) Min. aperture: 5.0" Total Observations (Recent): 58 (4) O-C: -0.03 ± 0.48 minutes	RA: 08:15:47.9805 hours (J2000) DEC: +05:50:12.352 degrees (J2000) Mag_R: 10.104 mag $Depth_R$: 11.97 mmag Duration: 2.25 hours	2025/02/22 21:26 Alt: 70° Azi: 153° (SE) HA: 23.41h	2025/02/22 22:26 Alt: 71° Azi: 200° (S) HA: 0.42h	2025/02/22 23:33 Alt: 62° Azi: 235° (SW) HA: 1.54h	2025/02/23 00:41 Alt: 48° Azi: 252° (W) HA: 2.67h	2025/02/23 01:41 Alt: 34° Azi: 261° (W) HA: 3.68h	Meridian crossing at: 2025/02/22 21:58 Max counts increase during observation: **R:0% V:0%** Moon illumination: **31.7%**, Moon distance: **136.8°**		
HD93963Ac (HIGH) Min. aperture: 40.91" Total Observations (Recent): 0 (0) O-C: -	RA: 10:51:06.5136 hours (J2000) DEC: +25:38:28.189 degrees (J2000) Mag_R: 8.821 mag $Depth_R$: 0.94 mmag Duration: 2.27 hours	2025/02/22 19:49 Alt: 25° Azi: 72° (E) HA: 19.2h	2025/02/22 20:49 Alt: 39° Azi: 75° (E) HA: 20.21h	2025/02/22 21:57 Alt: 54° Azi: 78° (E) HA: 21.34h	2025/02/22 23:05 Alt: 69° Azi: 79° (E) HA: 22.48h	2025/02/23 00:05 Alt: 83° Azi: 71° (E) HA: 23.48h	Max counts increase during observation: **R:13% V:28%** Moon illumination: **32.3%**, Moon distance: **111.2°**		
TOI-1272b (HIGH) Min. aperture: 25.69" Total Observations (Recent): 6 (0) O-C: -2.94 ± 1.2 minutes	RA: 13:16:47.1902 hours (J2000) DEC: +49:51:39.739 degrees (J2000) Mag_R: 11.618 mag $Depth_R$: 2.97 mmag Duration: 1.57 hours	2025/02/22 21:38 Alt: 23° Azi: 44° (NE) HA: 18.61h	2025/02/22 22:38 Alt: 33° Azi: 45° (NE) HA: 19.61h	2025/02/22 23:25 Alt: 41° Azi: 43° (NE) HA: 20.4h	2025/02/23 00:13 Alt: 48° Azi: 40° (NE) HA: 21.18h	2025/02/23 01:13 Alt: 56° Azi: 32° (NE) HA: 22.19h	Max counts increase during observation: **R:13% V:28%** Moon illumination: **31.7%**, Moon distance: **97.7°**		
NGTS-10b (LOW) Min. aperture: 12.28" Total Observations (Recent): 19 (4) O-C: -3.62 ± 0.31 minutes	RA: 06:07:29.3376 hours (J2000) DEC: -25:35:41.676 degrees (J2000) Mag_R: 14.2 mag $Depth_R$: 27.81 mmag Duration: 1.09 hours	2025/02/22 19:55 Alt: 41° Azi: 181° (S) HA: 0.03h	2025/02/22 20:55 Alt: 39° Azi: 198° (S) HA: 1.03h	2025/02/22 21:27 Alt: 36° Azi: 207° (SW) HA: 1.58h	2025/02/22 22:00 Alt: 32° Azi: 214° (SW) HA: 2.13h	2025/02/22 23:00 Alt: 23° Azi: 226° (SW) HA: 3.13h	Max counts increase during observation: **R:0% V:0%** Moon illumination: **32.5%**, Moon distance: **125.3°**		
Qatar-6b (LOW) Min. aperture: 5.0" Total Observations (Recent): 42 (11) O-C: 6.52 ± 0.17 minutes	RA: 14:48:50.4764 hours (J2000) DEC: +22:09:09.160 degrees (J2000) Mag_R: 11.161 mag $Depth_R$: 19.68 mmag Duration: 1.59 hours	2025/02/22 23:48 Alt: 25° Azi: 75° (E) HA: 19.23h	2025/02/23 00:48 Alt: 38° Azi: 80° (E) HA: 20.24h	2025/02/23 01:35 Alt: 49° Azi: 83° (E) HA: 21.03h	2025/02/23 02:23 Alt: 60° Azi: 86° (E) HA: 21.83h	2025/02/23 03:23 Alt: 74° Azi: 91° (E) HA: 22.83h	Max counts increase during observation: **R:13% V:27%** Moon illumination: **30.9%**, Moon distance: **66.2°**		

Each night there might be 10-ish transits to observe
(depends on location and telescope capability)

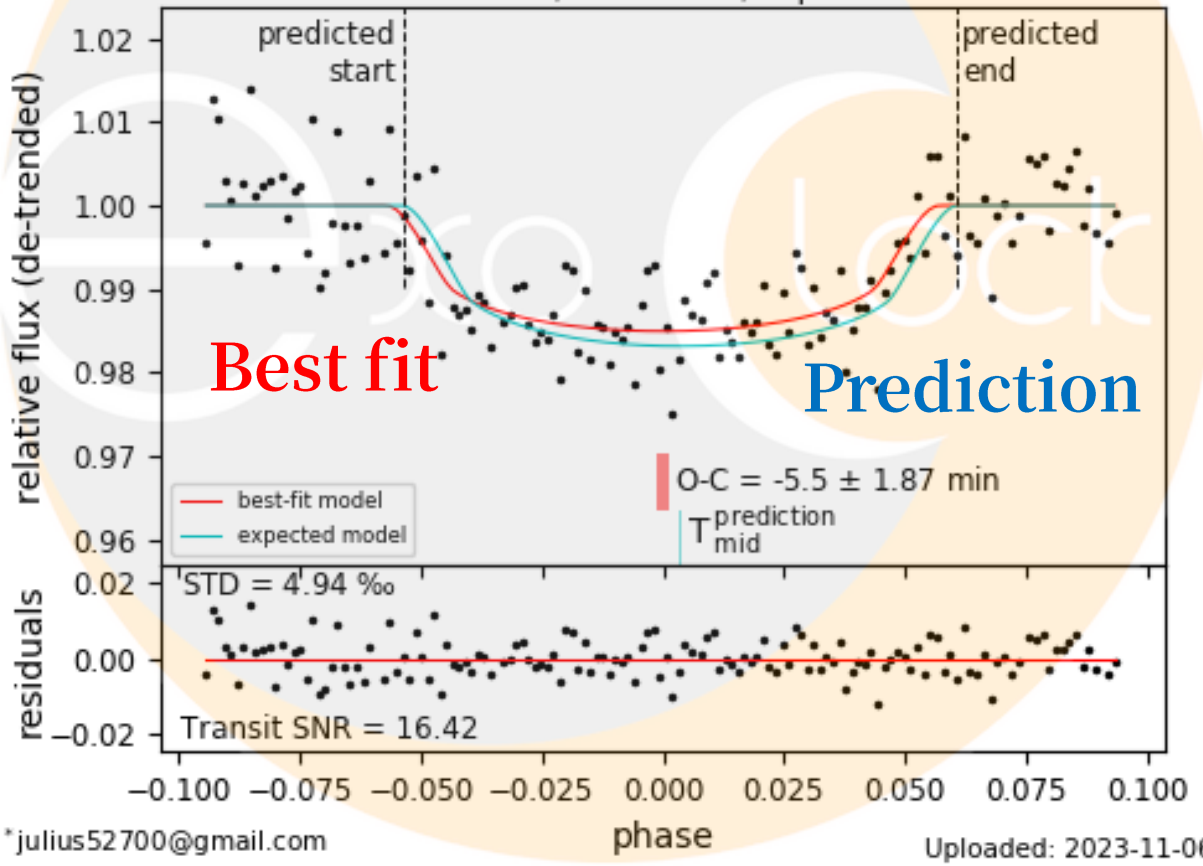


WASP – 12b

2023-11-05

Yen-Hsing Lin* (Institute of Astronomy, National Tsing Hua University), Shih-Ping Lai (Institute of Astronomy, National Tsing Hua University) on behalf of Taiwan astronomical Observation collaboration Platform (TOP)

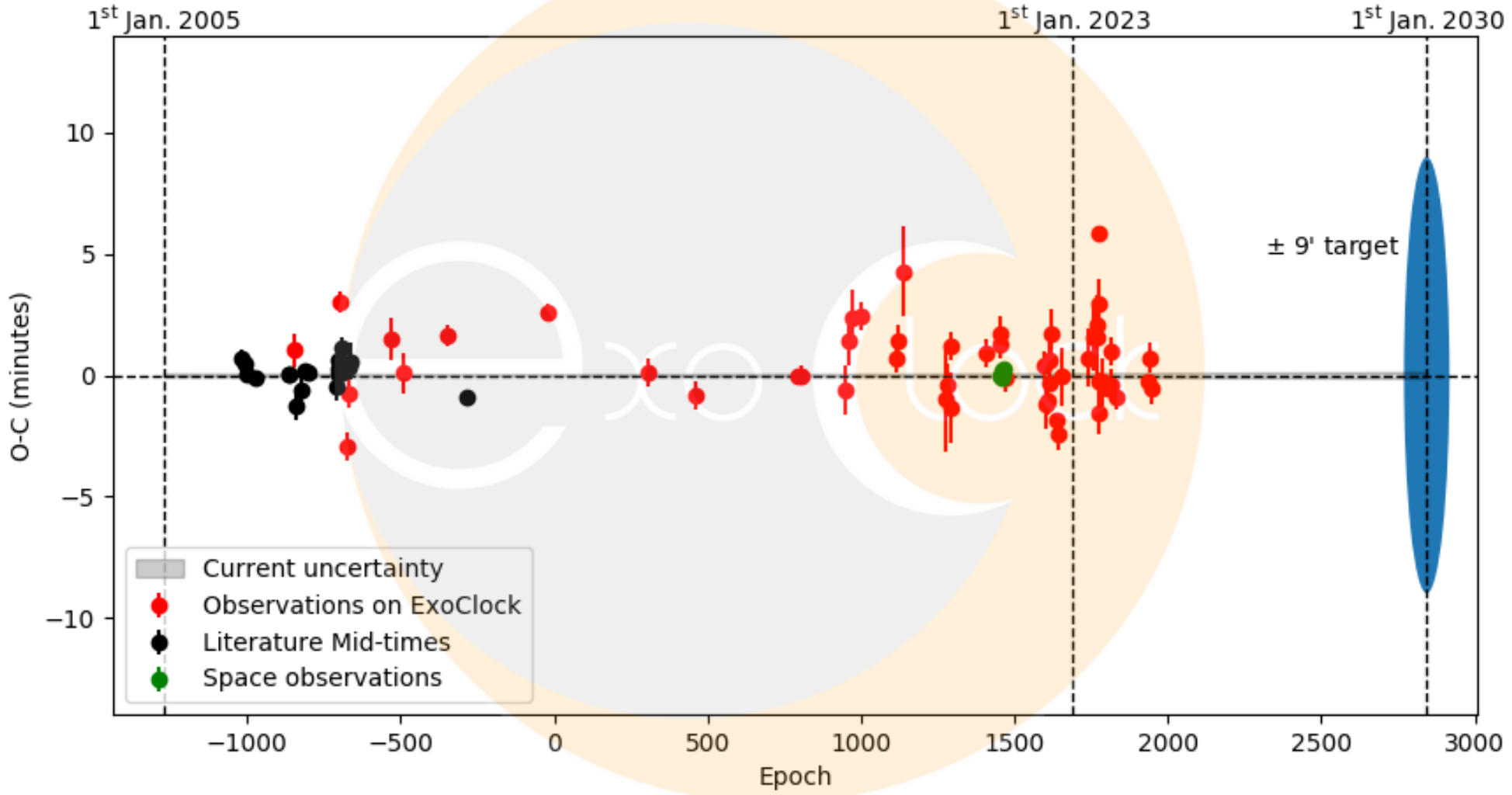
NTHU Observatory / Telescope: Showa 10 cm (5.0")
Camera: ASI183MC / Filter: Lum / Exp.: 120.0 s



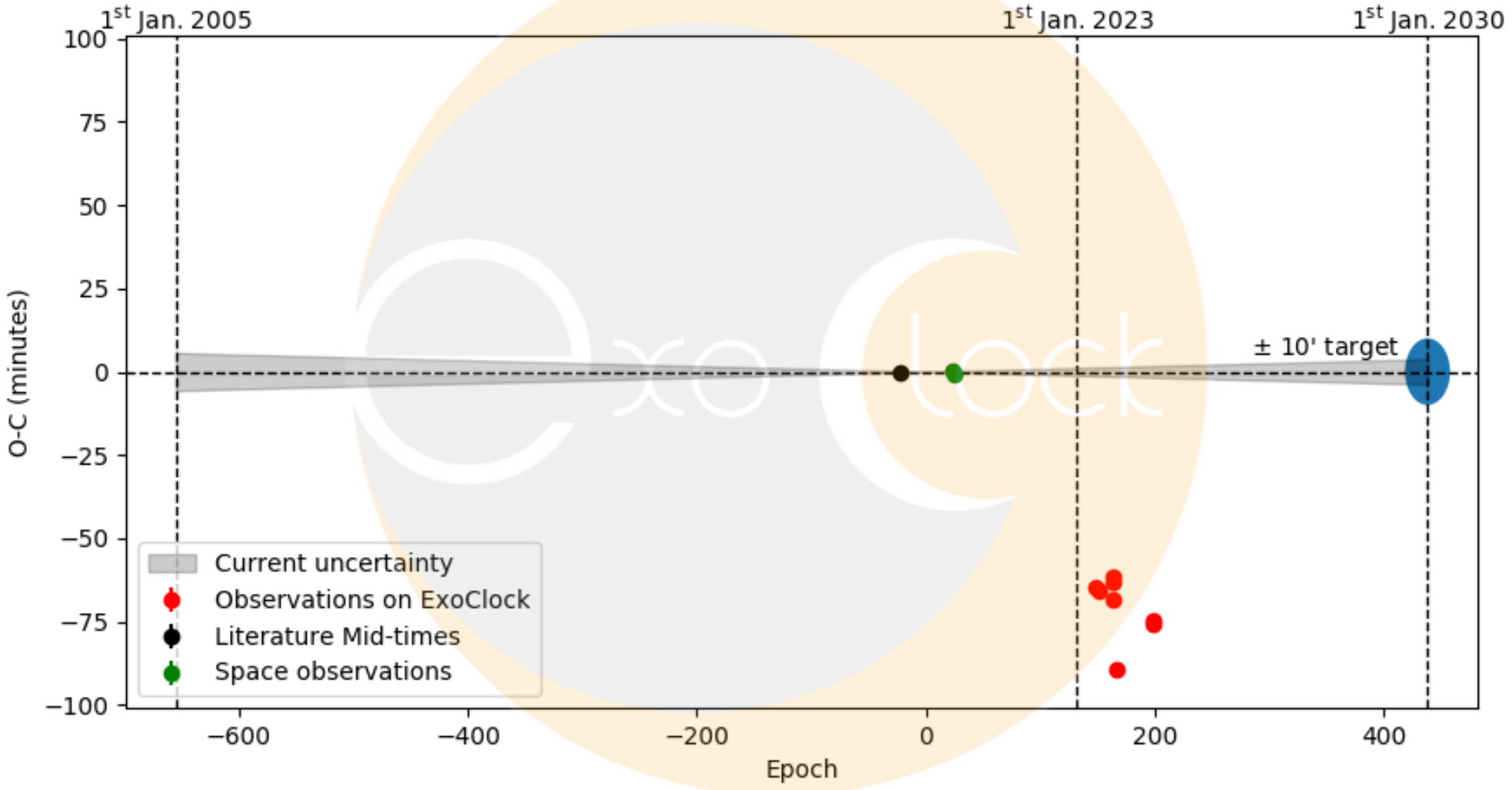
*julius52700@gmail.com

Uploaded: 2023-11-06

HD189733b: all is well



TOI-1130c: Ah oh...



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ExoClock Project. III. 450 New Exoplanet Ephemerides from Ground and Space Observations

A. Kokori[1], A. Tsiaras[1,2], B. Edwards[1,3], A. Jones[4,5], G. Pantelidou[6], G. Tinetti[1], L. Bewersdorff[4], A. Iliadou[6], Y. Jongen[4,7], G. Lekkas[8] Show full author list

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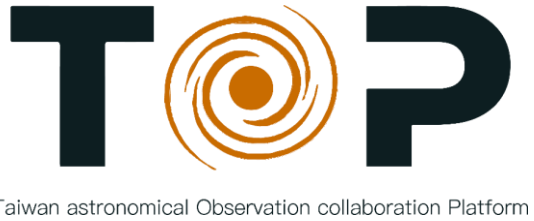
Article PDF Article ePub

A. Kokori[1], A. Tsiaras[1,2], B. Edwards[1,3], A. Jones[4,5], G. Pantelidou[6], G. Tinetti[1], L. Bewersdorff[4], A. Iliadou[6], Y. Jongen[4,7], G. Lekkas[8], A. Nastasi[9,10], E. Poultourtzidis[6], C. Sidiropoulos[8], F. Walter[4,11,12], A. Wünsche[13], R. Abraham[4,14], V. K. Agnihotri[4], R. Albanesi[4,15], E. Arce-Mansego[4,16], D. Arnot[17], M. Audejean[4], C. Aumasson[13], M. Bachschmidt[4], G. Baj[4], P. R. Barroy[4,18,19], A. A. Belinski[20], D. Bennett[4,5,21], P. Benni[4], K. Bernacki[22], L. Betti[23,24], A. Biagini[9,24,25], P. Bosch[26], P. Brandebourg[4], L. Brát[12], M. Bretton[13], S. M. Brincat[4,27], S. Brouillard[4,28], A. Bruzas[17], A. Bruzzone[4,29], R. A. Buckland[5,17,30], M. Caló[4], F. Campos[4], A. Carreño[4], J. A. Carrion Rodrigo[4], R. Casali[4], G. Casalnuovo[4], M. Cataneo[31,32], C.-M. Chang[33], L. Changeat[4], V. Chowdhury[4], R. Ciantini[23,24], M. Cilluffo[4,31], J.-F. Coliac[4], G. Conzo[4,34], M. Correa[4,35,36], G. Coulon[4], N. Crouzet[99,37,38], M. V. Crow[4,5,30], I. A. Curtis[4], D. Daniel[4], B. Dauchet[4], S. Dawes[4,5,30], M. Deldem[4], D. Deligeorgopoulos[4,39], G. Dransfield[40], R. Dymock[4,5], T. Eenmäe[41], N. Esseiva[4], P. Evans[4,42], C. Falco[9], R. G. Farfán[4], E. Fernández-Lajús[43,44], S. Ferratfiat[13], S. L. Ferreira[4], A. Ferretti[4,29], J. Fiołka[22], M. Fowler[4,5,45], S. R. Futcher[4,5,46], D. Gabellini[4], T. Gainey[4], J. Gaitan[4], P. Gajdoš[47], A. García-Sánchez[4,48], J. Garlitz[4], C. Gillier[4,49], C. Gison[17], J. Gonzales[4], D. Gorshanov[50], F. Grau Horta[4], G. Grivas[6], P. Guerra[26], T. Guillot[51], C. A. Haswell[17], T. Haymes[4,5], V.-P. Hentunen[52], K. Hills[4,5,53], K. Hose[4], T. Humbert[4], F. Hurter[4,54], T. Hynek[55], M. Irzyk[4], J. Jacobsen[4], A. L. Jannetta[4], K. Johnson[4], P. Jóźwik-Wabik[22], A. E. Kaeouach[4], W. Kang[56,57], H. Kiiskinen[4,58], T. Kim[56,59], Ü. Kivila[4,60], B. Koch[4], U. Kolb[17], H. Kučáková[12,61], S.-P. Lai[33,62], D. Laloum[4,27], S. Lasota[22], L. A. Lewis[17], G.-I. Liakos[4], F. Libotte[4,35,36], F. Lomoz[12,63], C. Lopresti[4,64], R. Majewski[4], A. Malcher[22], M. Mallonn[65], M. Mannucci[4,66], A. Marchini[67], J.-M. Mari[4,68], A. Marino[4,69], G. Marino[4,70], J.-C. Mario[4], J.-B. Marquette[71], M. Martínez-Bravo[4], M. Mašek[12,72], P. Matassa[4], P. Michel[4], J. Michelet[4], M. Miller[4,5,27], E. Miny[4,73], D. Molina[4,74], T. Mollier[4], B. Monteleone[4], N. Montigiani[4,66], M. Morales-Aimar[4,27,75], F. Mortari[4], M. Morvan[1], L. V. Mugnai[10,76],



Techniques

Opportunity

Clear goal

Independent contributor to the ExoClock Project using multiple Taiwanese observatories

Night

10:00 p.m.

Setup observation sequence

03:00 a.m.

My Friend in Taiwan starts the observation for me.

Day

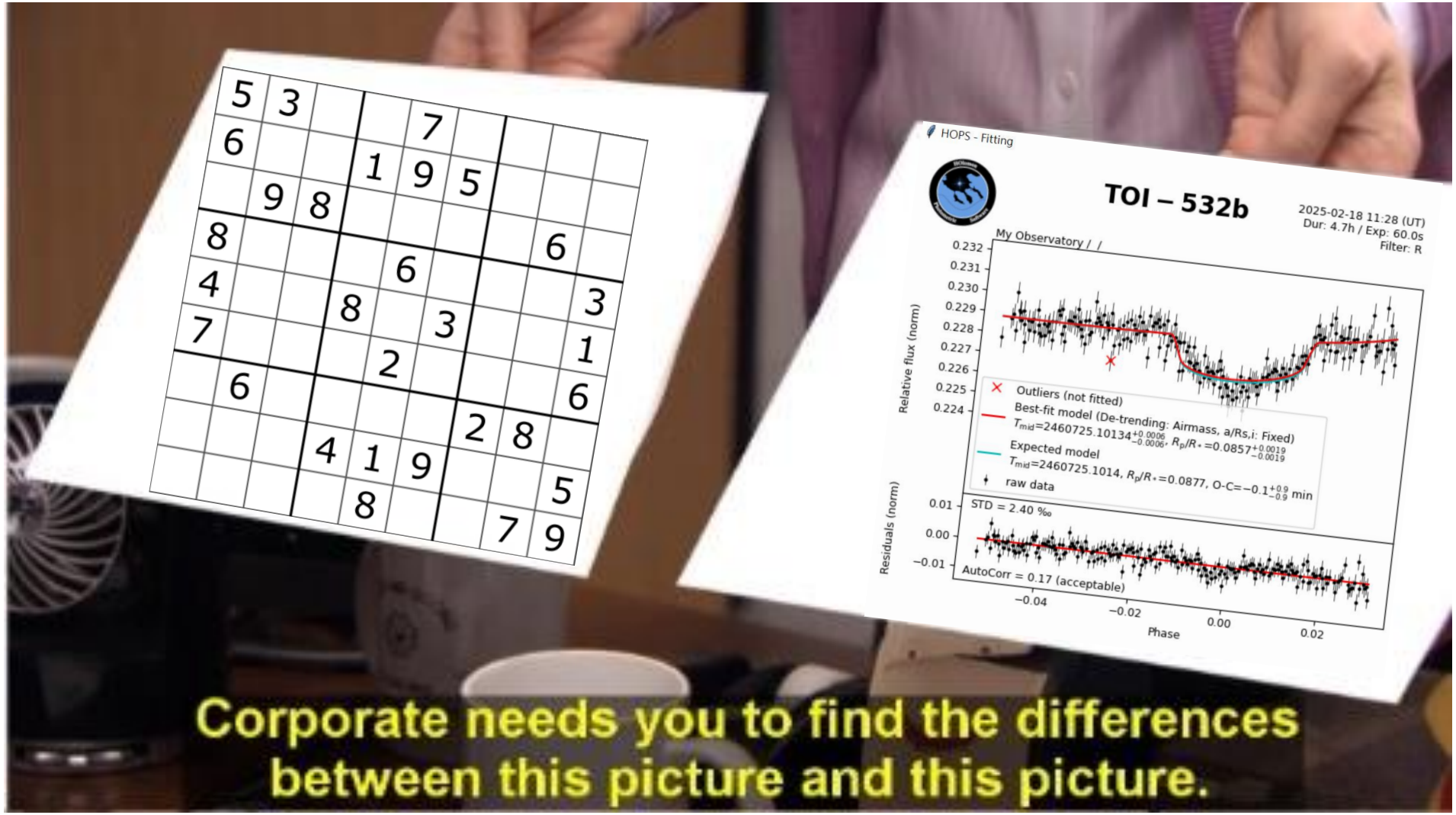
08:00 a.m.

I wake up and take over, my friend go to sleep

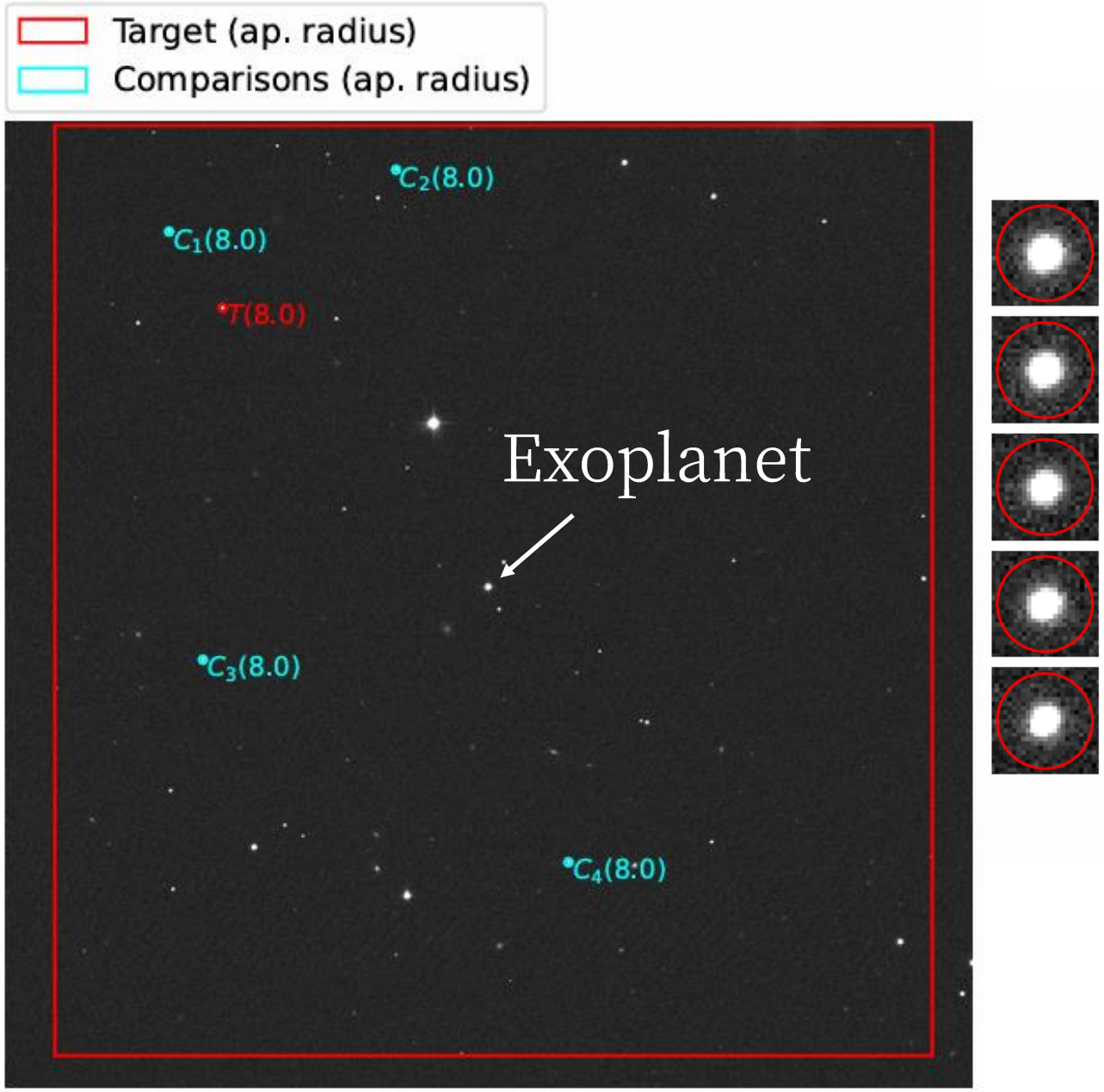
01:00 p.m.

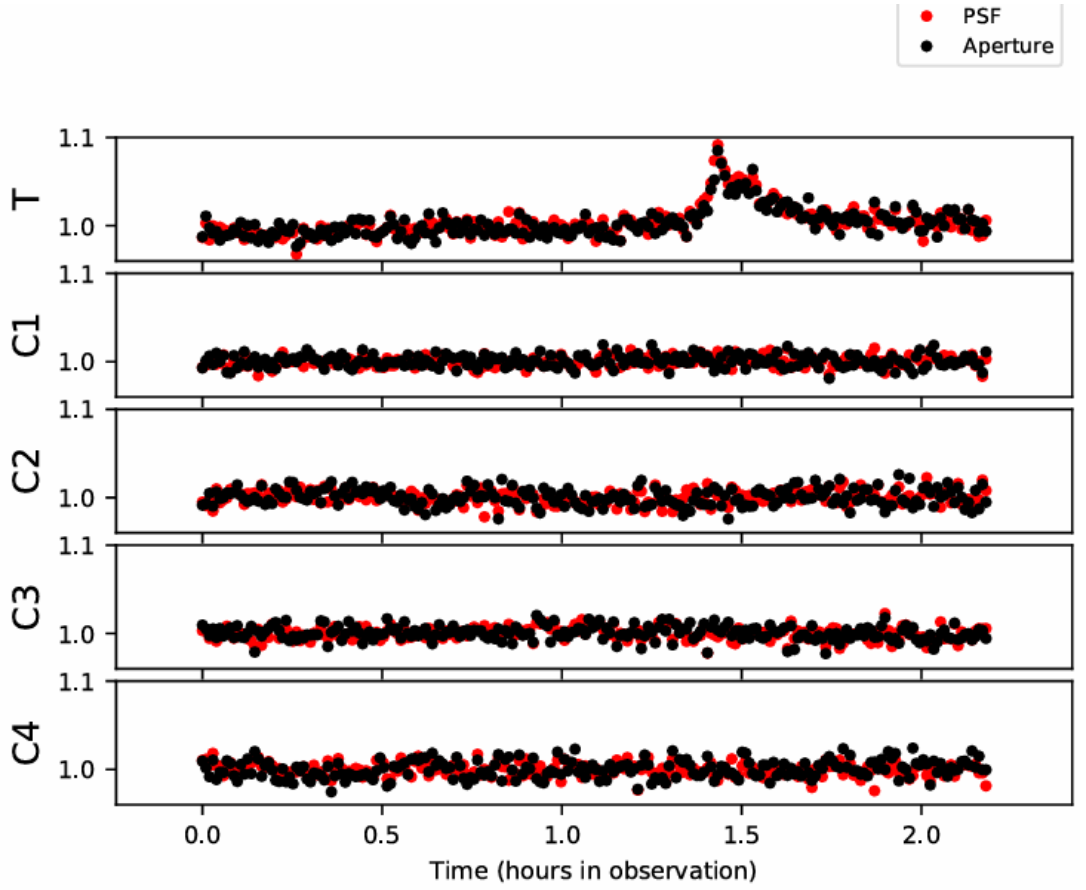
Data analysis

Submit the results

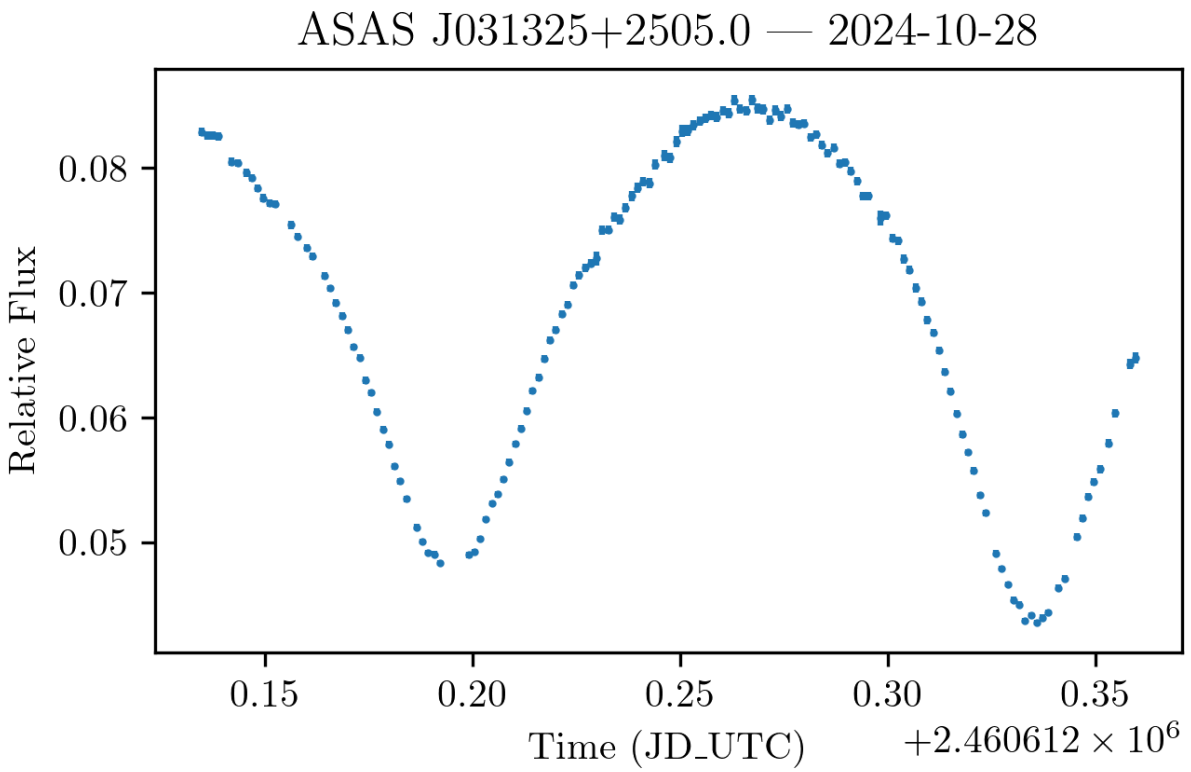


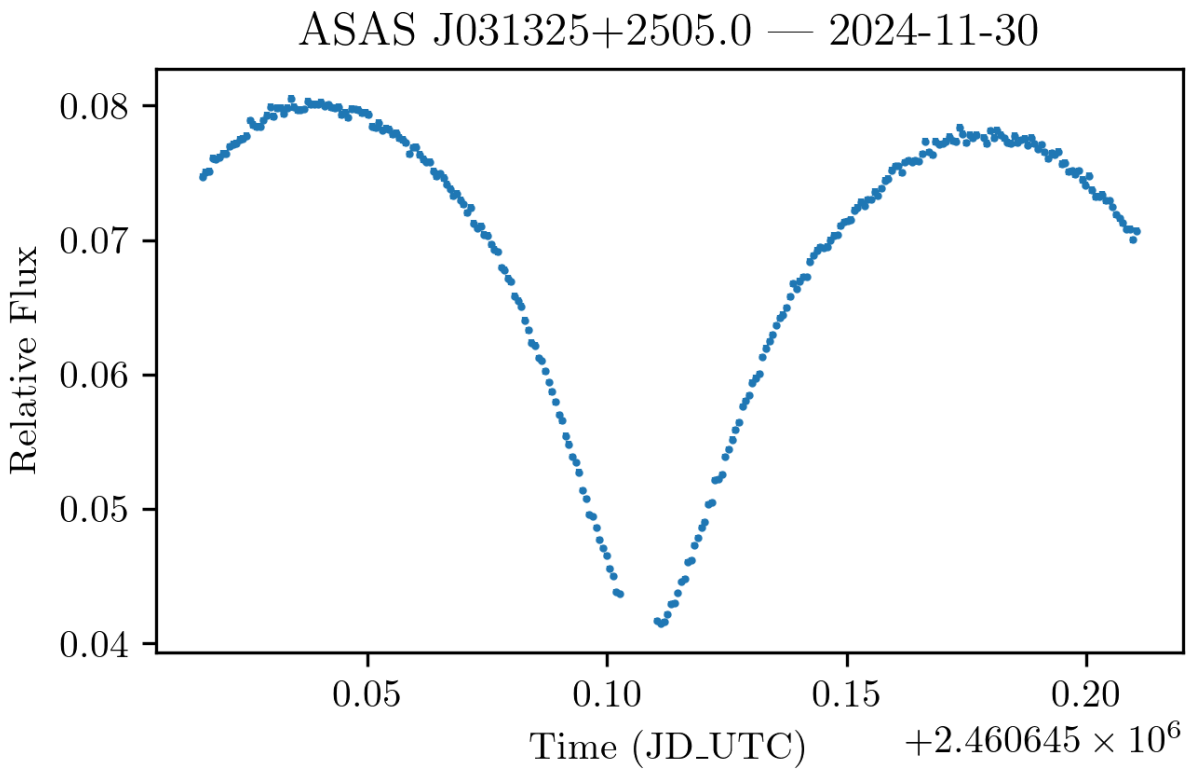
They are the same picture



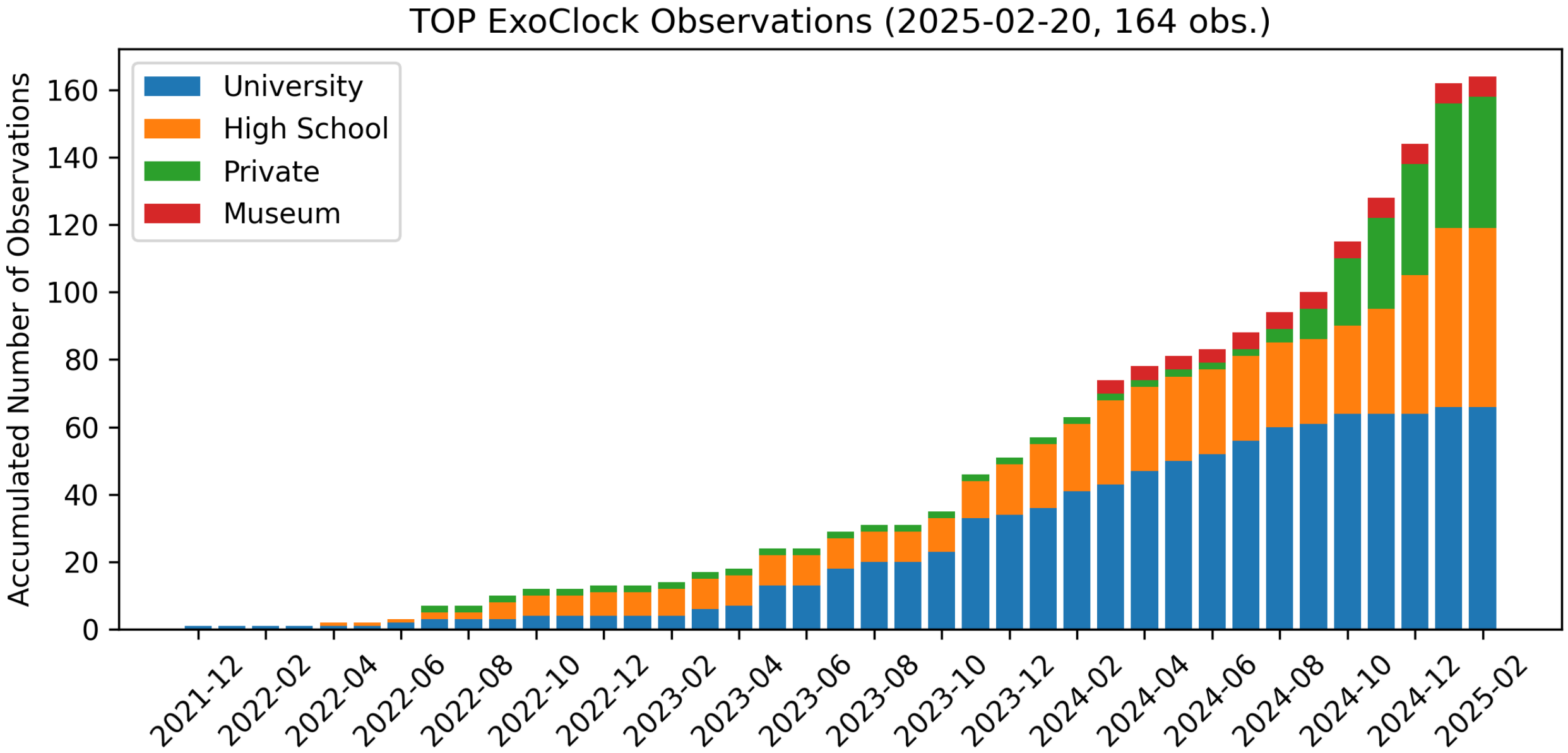


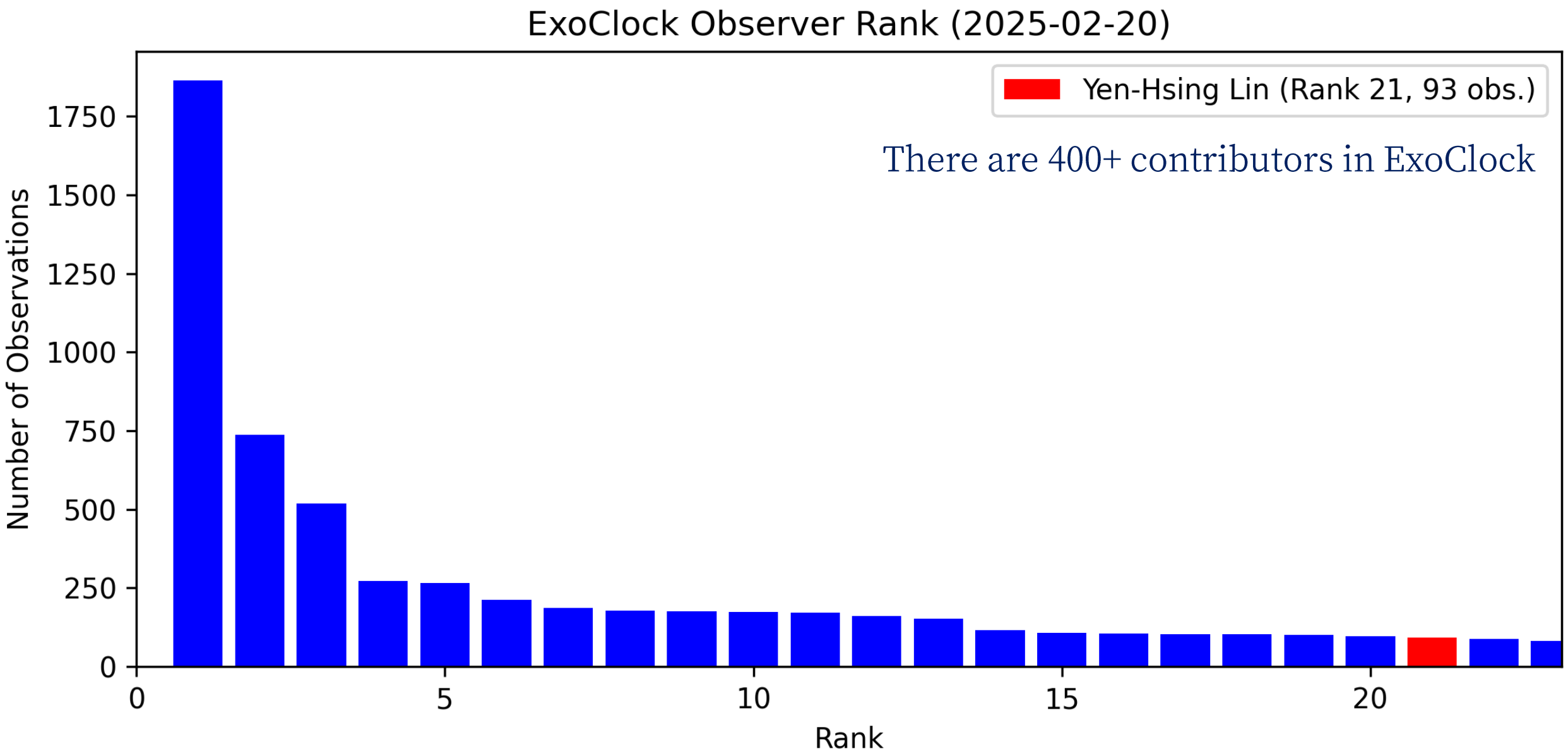
Is that a stellar flare?





Eclipsing binary ASAS J031325+2505.0


TOP ExoClock Observations (2025-02-20, 164 obs.)
Accumulated Number of Observations
University
High School
Private
Museum
0
20
40
60
80
100
120
140
160
2021-12
2022-02
2022-04
2022-06
2022-08
2022-10
2022-12
2023-02
2023-04
2023-06
2023-08
2023-10
2023-12
2024-02
2024-04
2024-06
2024-08
2024-10
2024-12
2025-02


ExoClock Observer Rank (2025-02-20)
Yen-Hsing Lin (Rank 21, 93 obs.)
There are 400+ contributors in ExoClock
Number of Observations
0
250
500
750
1000
1250
1500
1750
0
5
10
15
20
Rank

A step further: writing proposals

Since mid-2024, I have been applying to Lulin One-meter Telescope (LOT) to do ExoClock observations (2024B, 2024C, 2025A).

Pushing for more challenging targets (aperture > 20 inches required).

Not just for myself

- I recruit (?) 2 young talented (academia + amateur) students as my Co-I.
- I get the data, they get the chance to enjoy the observations.
- I also asked them to bring other students (from e.g. various astronomy clubs) to learn about observational astronomy.

Program ID S156 | PI: Yu-Hsiu Huang

2 nights at Steward Observatory 61 inches telescope

Summary

- How I became an amateur planet hunter?
  - NTHU Astronomy club: teaches me the techniques.
  - TOP 2022 summer camp: provides the opportunity.
  - ExoClock: clear goal and rewards.
- Playing around with the real observation data is refreshing.
- If you happens to have some telescopes but not knowing what to do about them, joining ExoClock might be a decent direction.