Stellar Occultations by Asteroids Observed with the Unistellar Network:
The Cases of (16583) Oersted and 2013 LU28

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Contributors:

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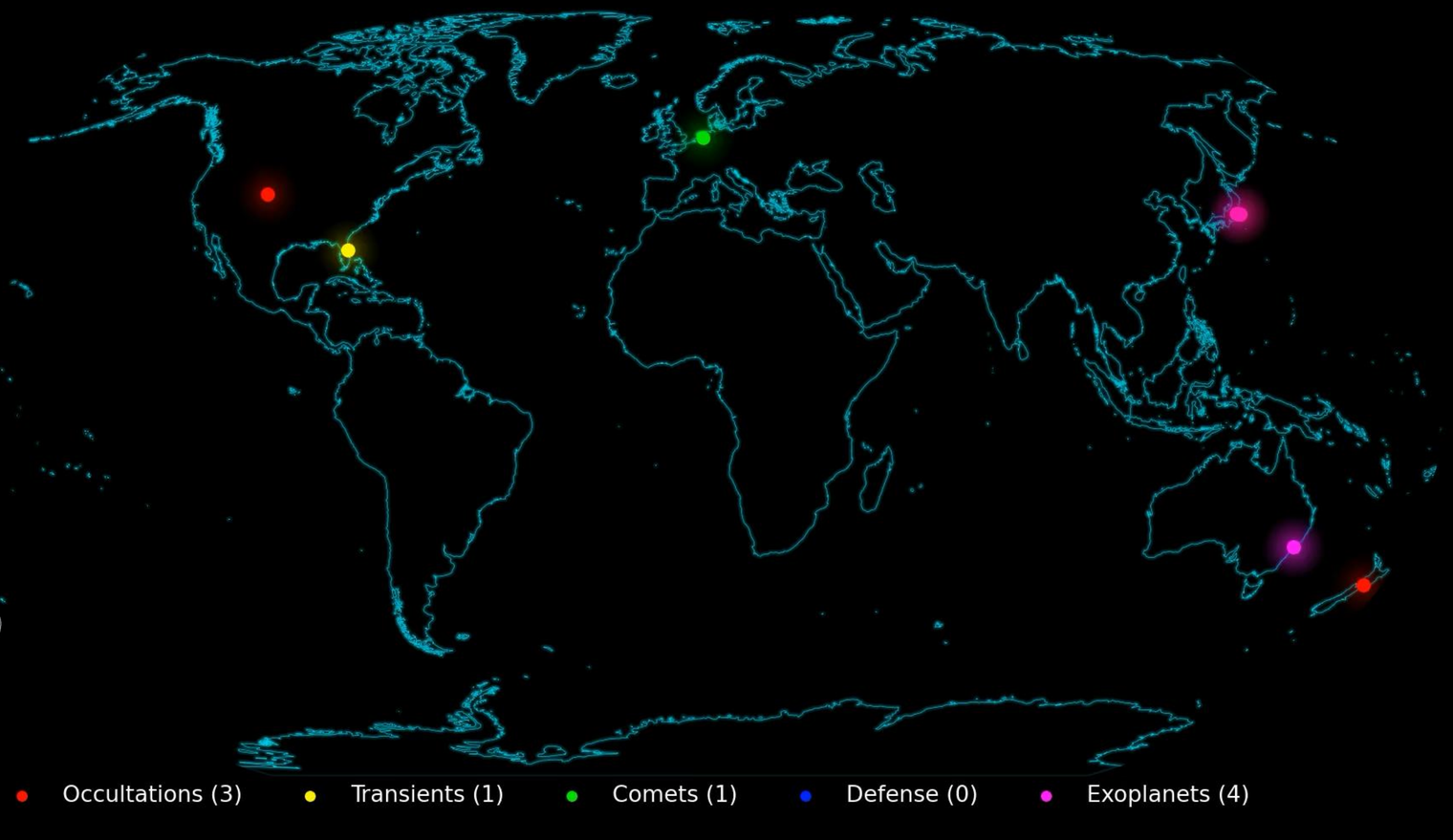
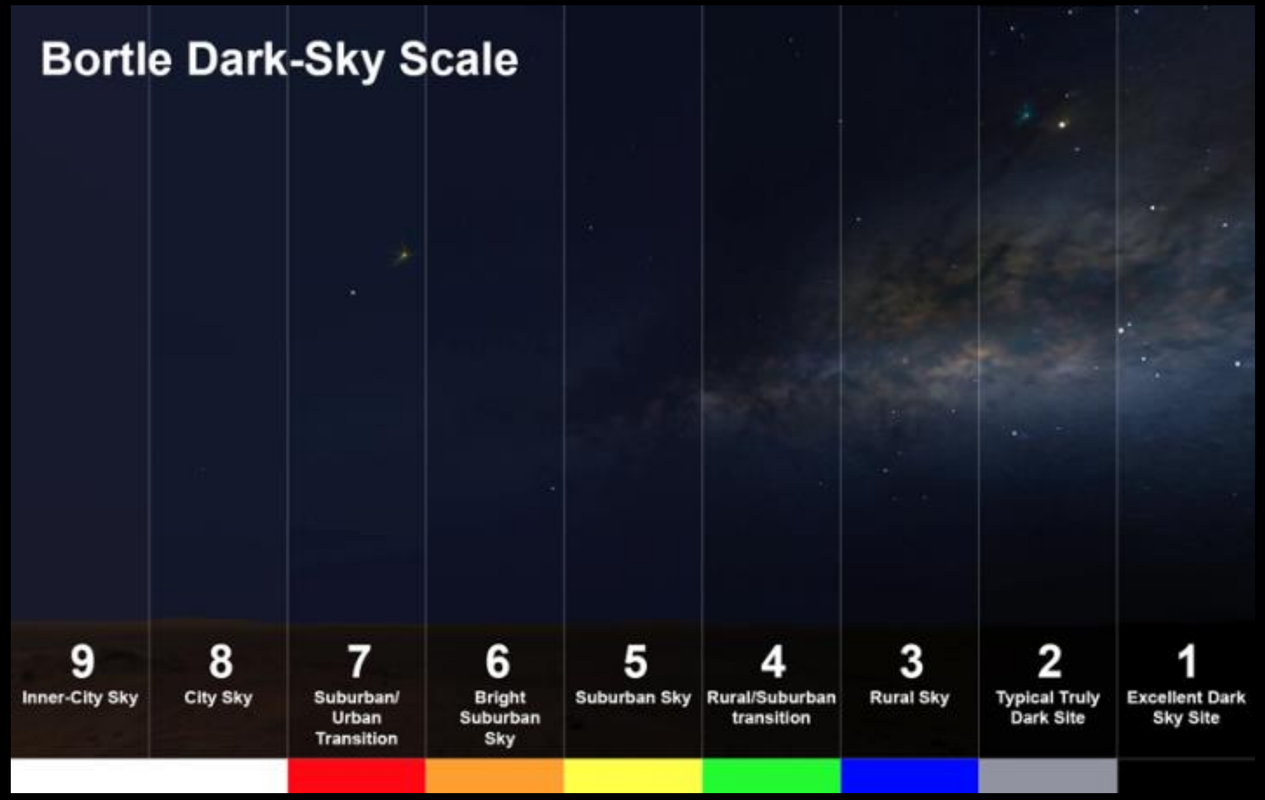
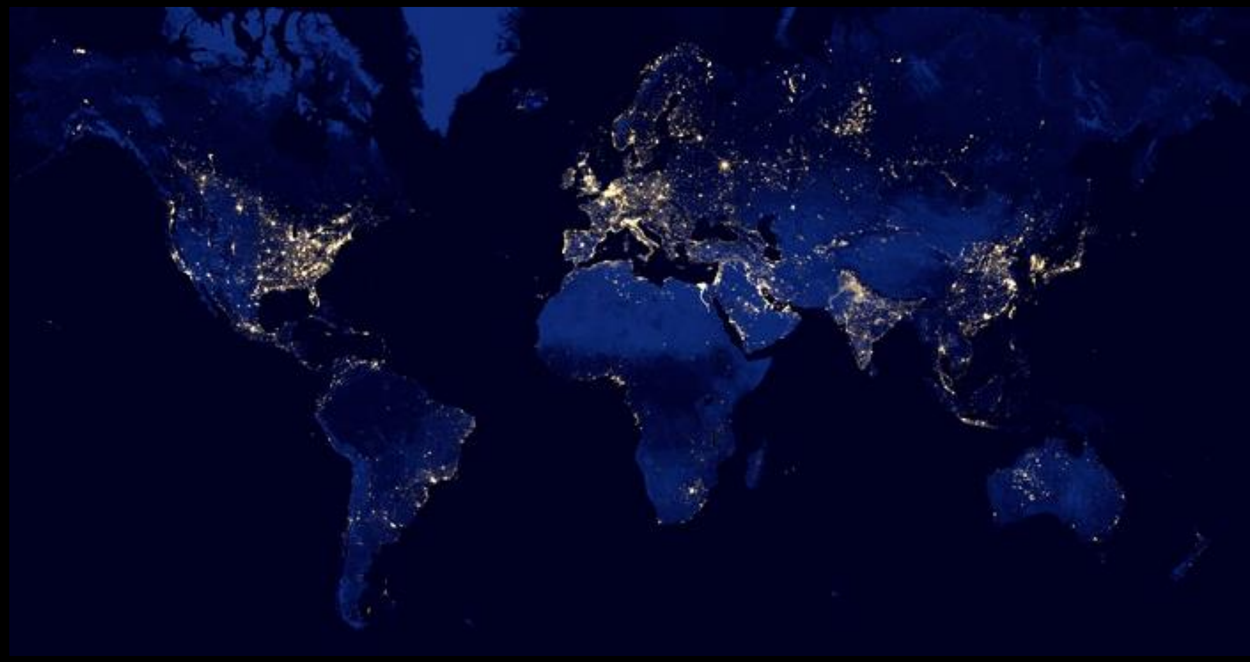


The Cosmic Blindness



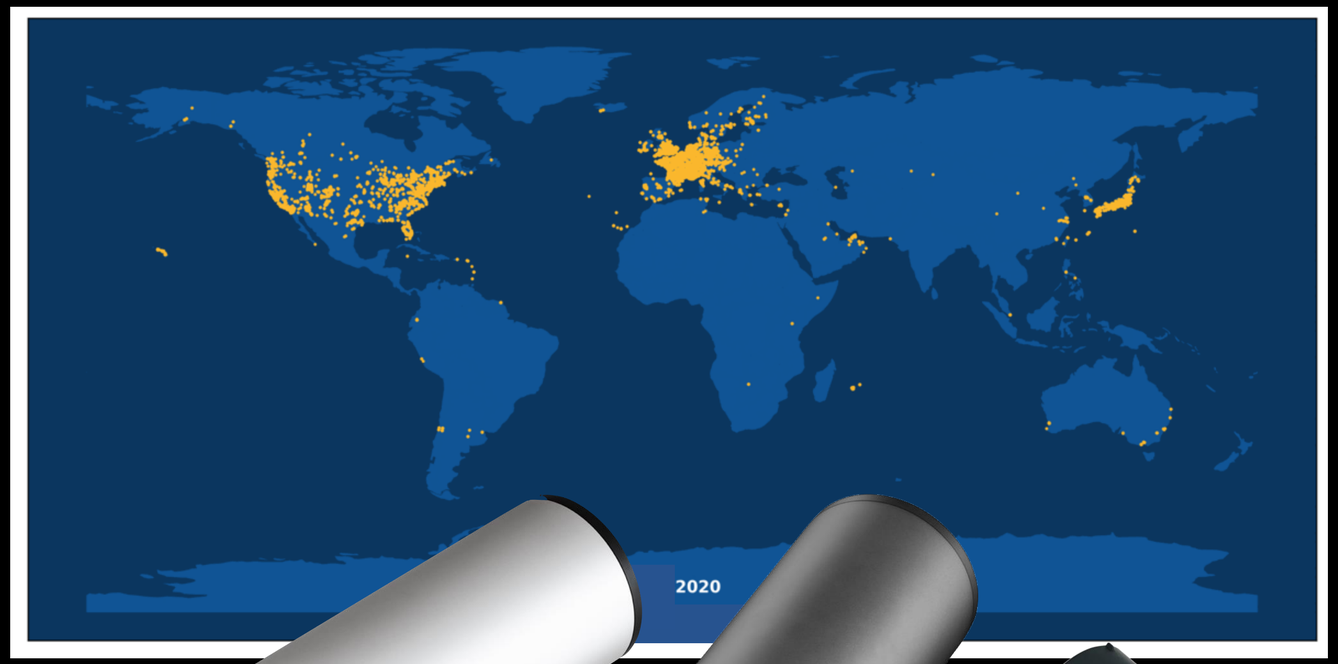
80% of humanity



- **Aims:** Finding a workaround for people living in light-polluted areas
- **Methods:** Kickstarter campaign to develop a smart telescope with enhanced vision technology (2017, >$2M)
- **Results:** >15,000 smart telescopes delivered to customers, largest network of citizen astronomers

Unistellar

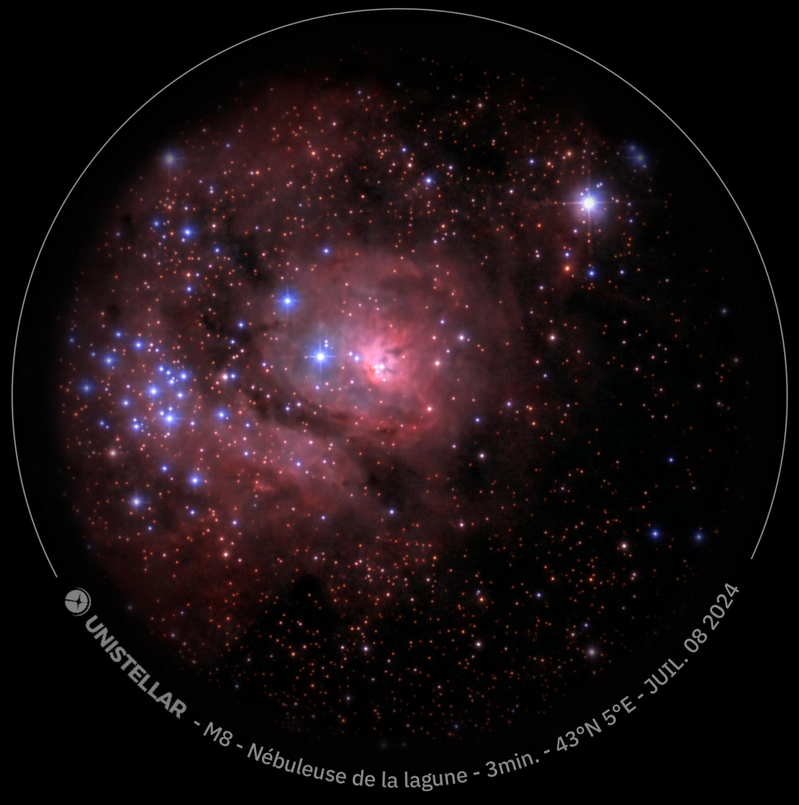
Spec & Citizen Science



- eVscopes
  - Control with phone app
  - Autonomous field detection
  - Real time stacking
  - Aperture: 114 mm, 85 mm
- Network > 15,000 eVscopes
- Science Campaigns:
  - Transients
  - Exoplanets
  - Occultations
  - Comets
  - Planetary Defense
  - Satellites (artificial)

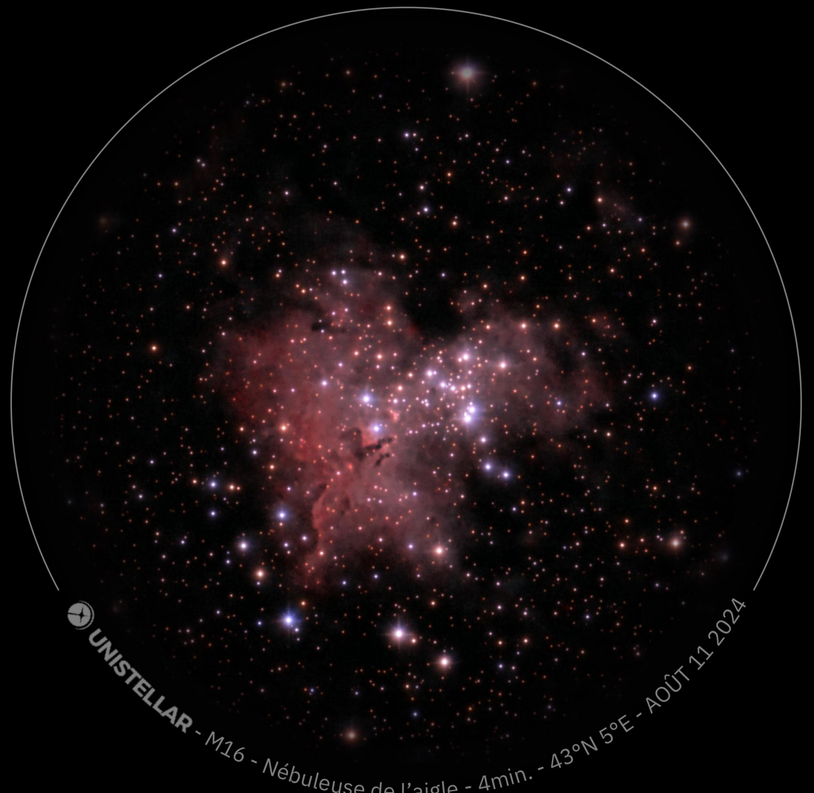
ODYSSEY/ODYSSEY Pro	Evscope 1/ eQuinox	Evscope 2/ eQuinox 2
34’ x 45’ FOV	37’ x 28’ FOV	47’ x 34’ FOV
0.93“/pix	1.72 “/pix	1.33 “/pix
Sony IMX415	Sony IMX224	Sony IMX347

"Come for the images, Stay for the Science"



Lagoon Nebula

Centaurus A



Eagle nebula +

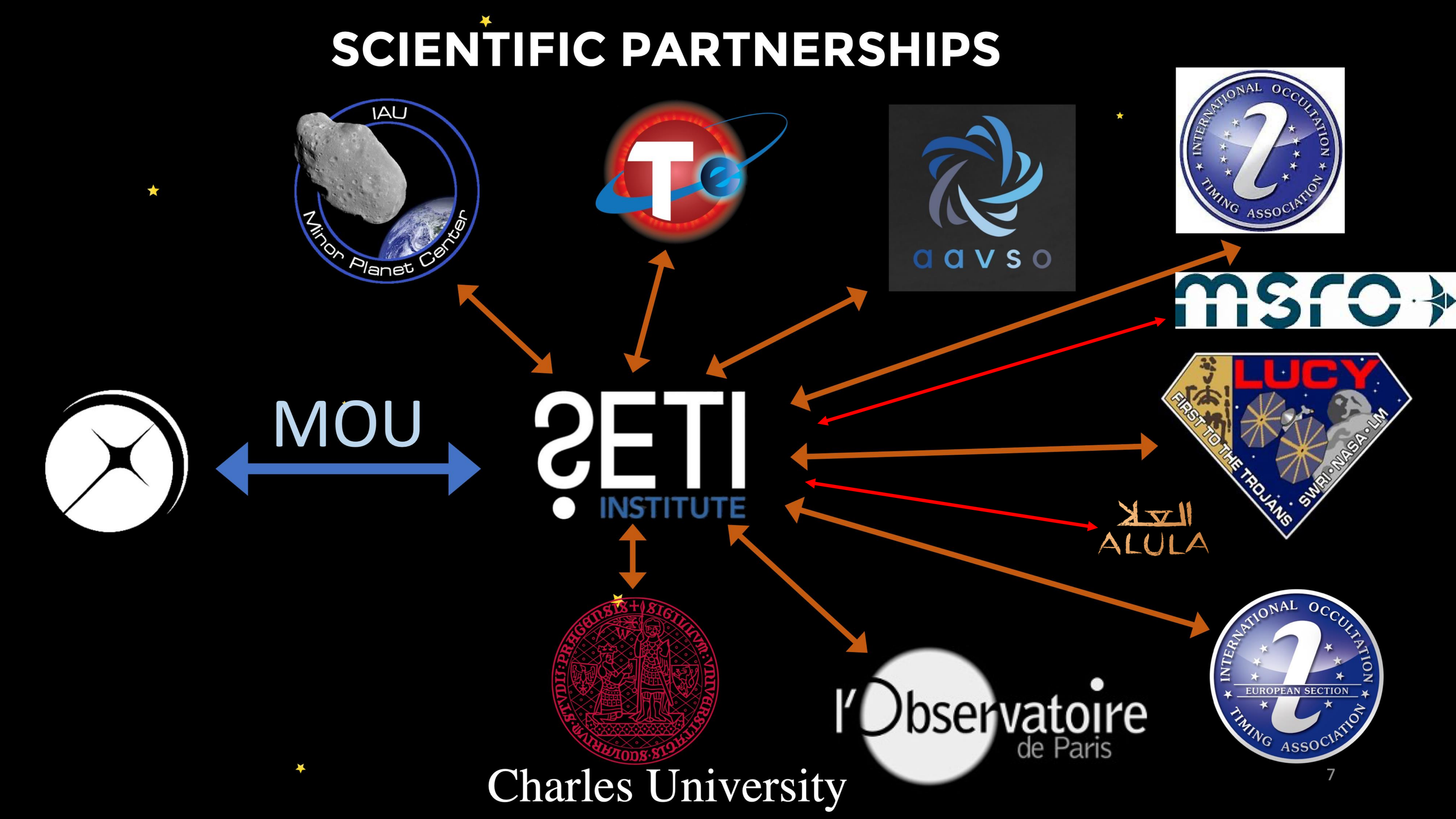
Pillars of creation

New image processing called “Vivid Vision” was released in October 2024

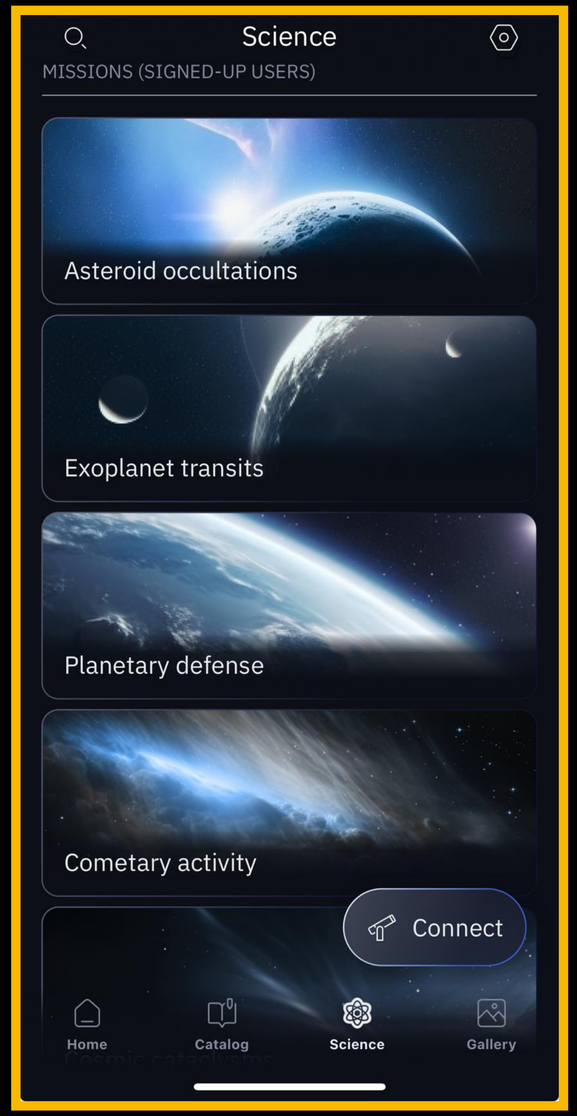
SCIENCE!

UNISTELLAR + SETI INSTITUTE

SCIENTIFIC PARTNERSHIPS



Making it Easy to Become a Citizen Astronomer



Easy to use Science mode in the Unistellar App

Location tailored predictions

Visibility maps

Co-founder of Unistellar
Chief Scientific Officer
Dr. Franck Marchis

Comet Lead
Dr. Ariel Graykowski

Outreach + Education
Dr. Ian Weaver

Occultation Lead
Dr. Josef Hanuš

Transient Lead
Science Team Lead
Dr. Tom Esposito

Exoplanet Lead
Dr. Lauren Sgro

Planetary Defense Lead
Dr. Ryan Lambert

Office Mascot
Stormy

SETI science Pipelines

User uploads data to remote GCP servers using the Unistellar app

Data runs through automatic pipelines which dark subtract, plate solve, and stack images (twice a day)

Differential photometry is performed using a median combination of many references stars

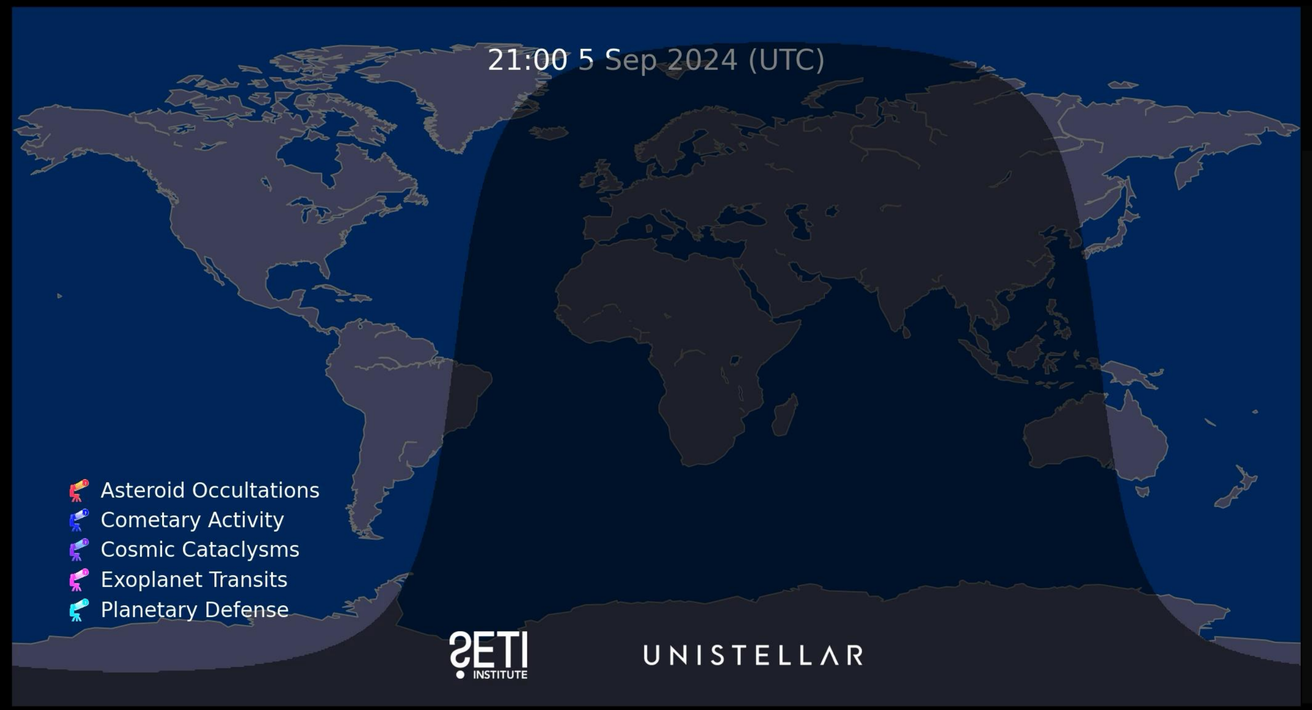
Lightcurves/transits are modeled and plotted in a report

Report is posted to Unistellar Citizen Science Slack

Web Site – hub for science

https://science.unistellar.com/

Live view of uploaded observations



Live view of processed data

Find Your Event | Asteroid Occultations | Comets | Cosmic Cataclysms | Exoplanets | Planetary Defense | Satellites | More

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SETI + Unistellar Network Data Processing Status

Campaign	Event	Event Date (UTC)	Telescope	Observation Status	City/Country	Start Time	End Time
EXOPLANET TRANSITS	20240903_transit_Qatar-1b_transit_03	September 3, 2024	9vr	Processing	Highland Park, US, New Jersey	6 Sep 15:07	
	20240906_transit_WASP-52b	September 6, 2024	8cm	Failure		6 Sep 14:58	6 Sep 14:58
	20240906_transit_WASP-52b_transit_06	September 6, 2024	8cm	Processing	Shimoishii, Japan	6 Sep 14:19	
COSMIC	20240906_transient_TXDel	September 6, 2024	v8v	Success	Nagakunidai, Japan	6 Sep 13:05	6 Sep 13:14
	20240906_transient_SVul	September 6, 2024	8cm	Success	Shimoishii, Japan	6 Sep 13:00	6 Sep 13:05

Useful information – description of scientific modes, their aims, guidelines, predictions, etc. Open access. New feature: user accounts.

Occultations

- Science Goals:
  - Improvements of the orbits
  - Physical characterization - size and shape. Direct method for size determination
- With Unistellar Network:
  - Map the shape and size of an asteroid
  - Refine the orbit for future observations (improved predictions)
  - Detection of satellites (1 CBET), rings, double stars, diffraction effects, etc.

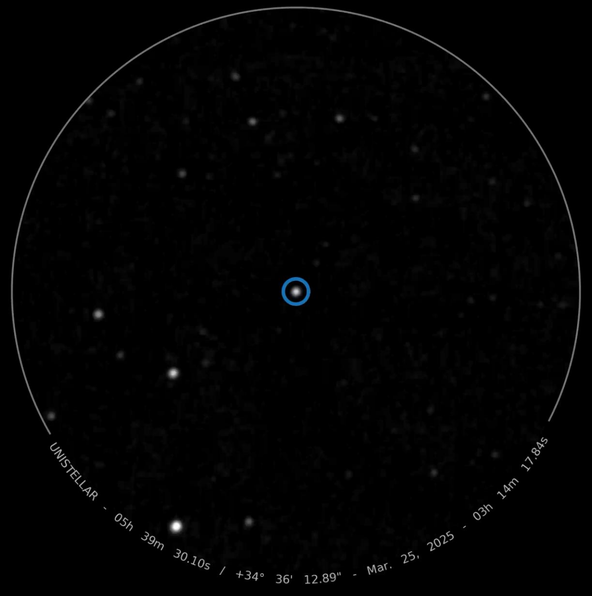
Occultations

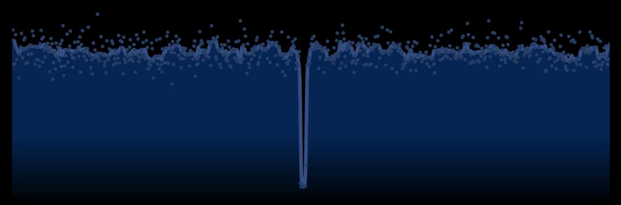
Occultation by (541) Deborah

by Margaret Loose on Apr. 3, 2025

Occultation by (759) Vinifera

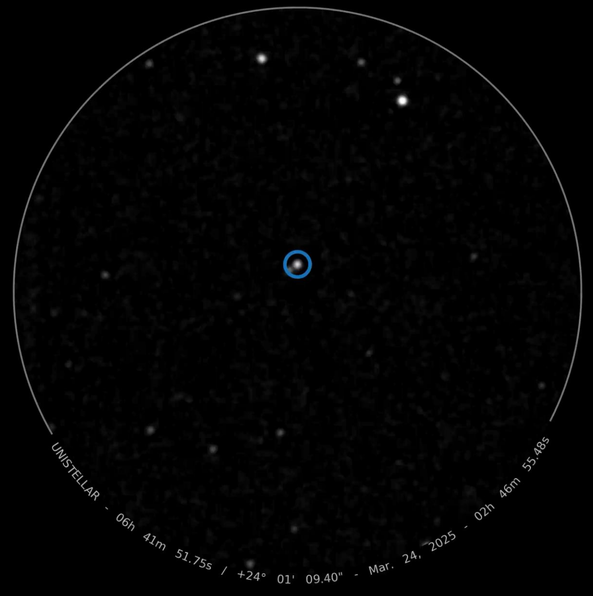
by Margaret Loose on Mar. 25, 2025

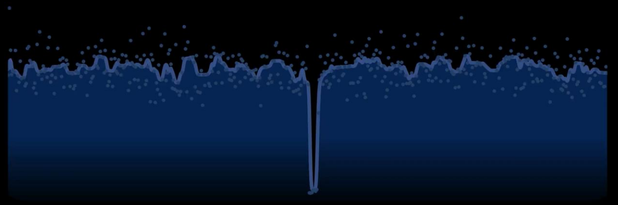




Occultation by (54428) 2000 LN27

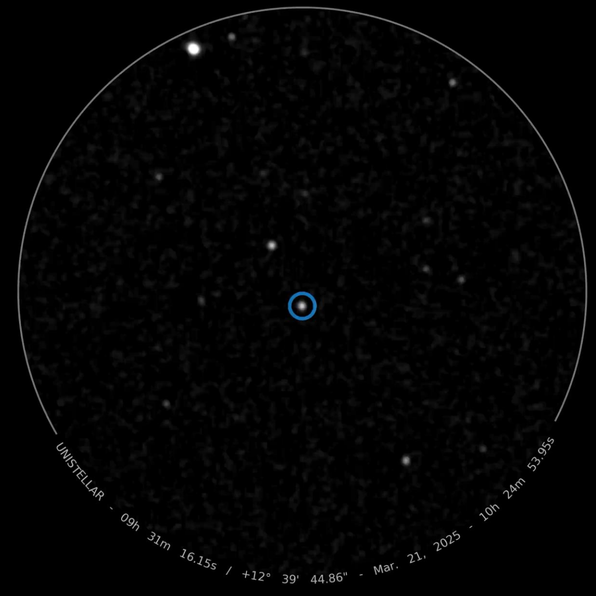
by Margaret Dunford on Mar. 24, 2025

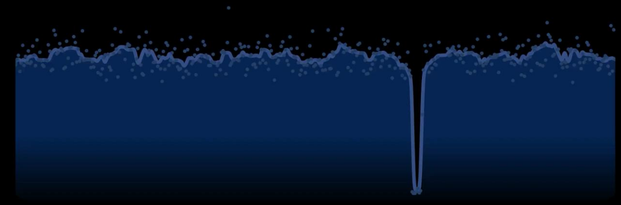




Occultation by (2390) Nezarka

by Andrew Wendelborn on Mar. 21, 2025



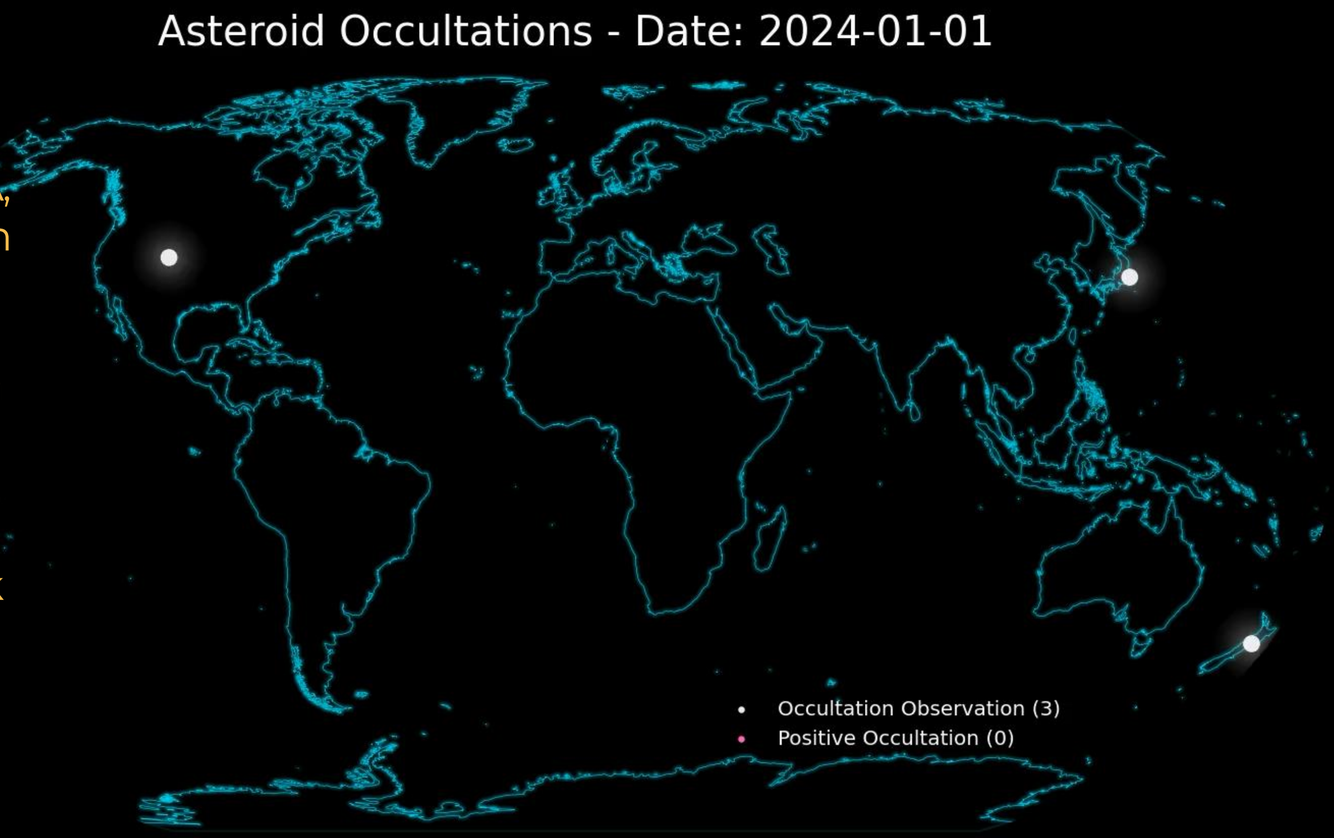


Occultations

- How:

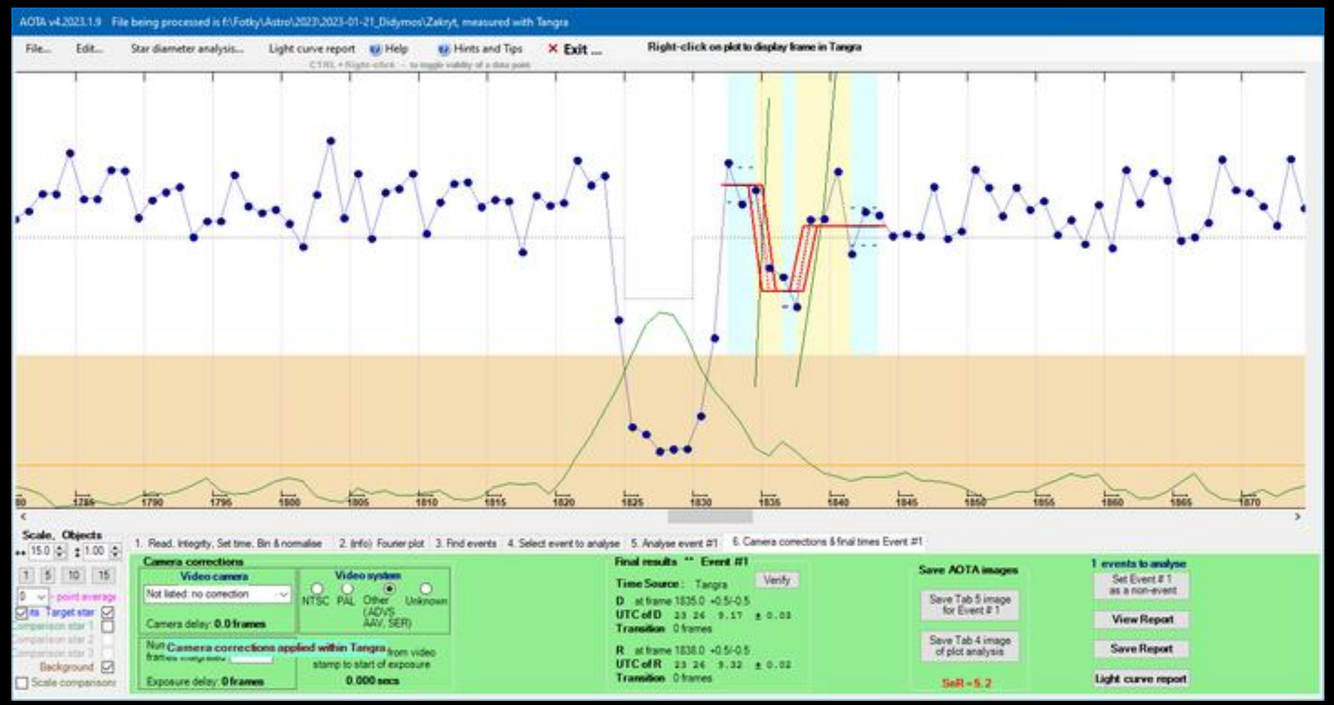
UNISTELLAR

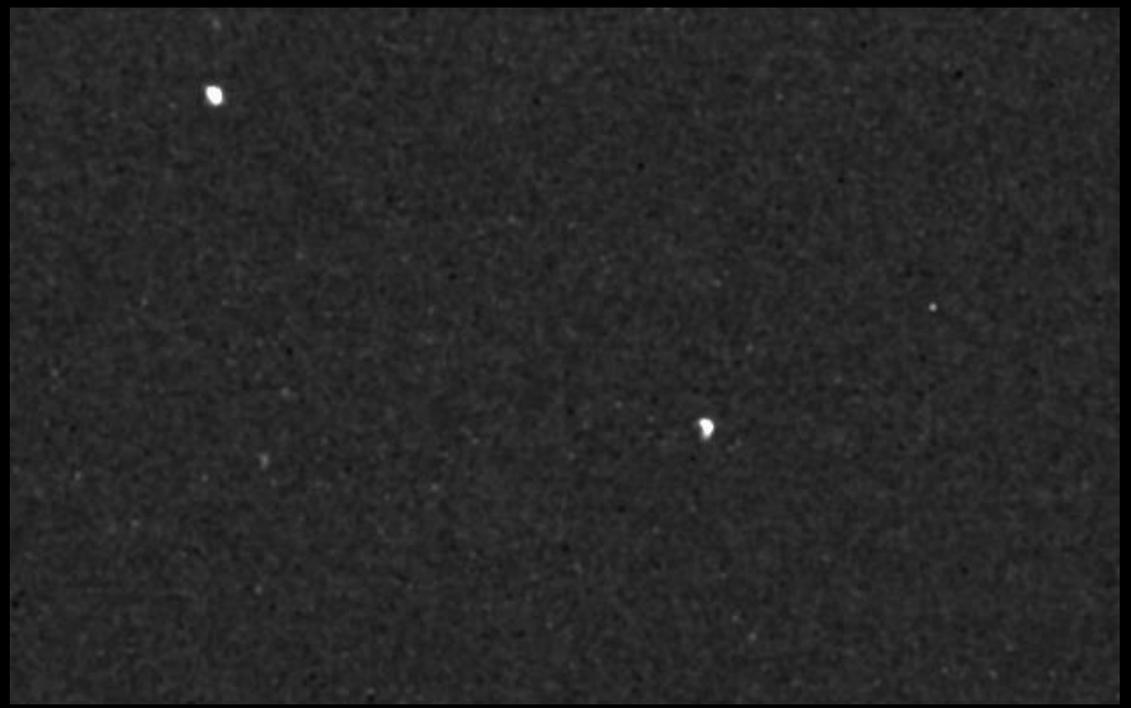
  - We provide predictions tailored for selected location, together with observation setup via an App deeplink (exposure time, duration, gain, RA, Dec), ~9,000 predictions worldwide each month
  - We can do up to 50 ms exposures and securely detect events for stars up to 12 magnitude (with 300 ms exposures)
  - We process data and then analyze the lightcurves with a convolutional neural network algorithm (ODNet, Cazeneuve et al. 2023)
  - We had about 400 observations in 2024, including 54 positive detections. We expect slightly higher values in 2025
  - Still some issues to solve… Detecting short events, filtering reliable results, reporting to IOTA, fixing technical issue sometimes causing dropping frames, etc.



Occultations

- Didymos & Dimorphos
  - We collaborate with ACROSS project from the University of Nice, France
  - They provide up-to-date predictions of targets of interest, for example, specific NEAs (Didymos, Phaethon) or TNOs
  - We detected occultation by both Didymos and Dimorphos by our eVscope 50ms exposures, bright star – 9 mag (Tanga et al., in prep)
  - Lightcurve is affected by diffraction





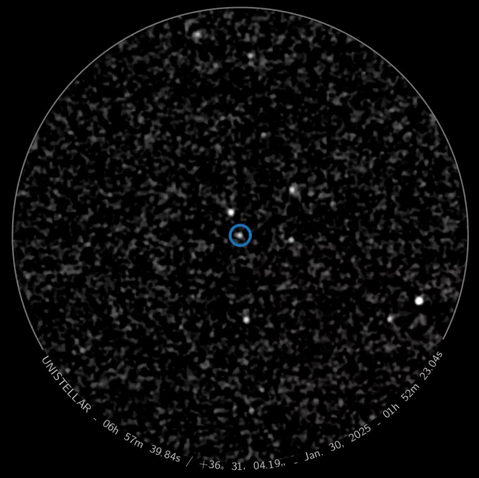
Didymos&Dimorphos: Lightcurve processed by Tangra/AOTA (left) and the movie depicting the event (right).

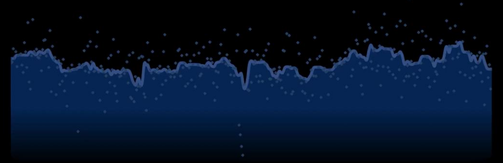
Occultations

- TNO 2013 LU28
  - Two chords for TNO 2013 LU28 (ACROSS event)
  - Night Jan 29/30 2025
  - 9 observations, 2+1 pos, 4 neg
  - Results provided to Dave Herald, data uploaded to ACROSS
  - Align nicely with the others (chords 13,19), after time shift correction for one observation

Occultation by (468861) 2013 LU28

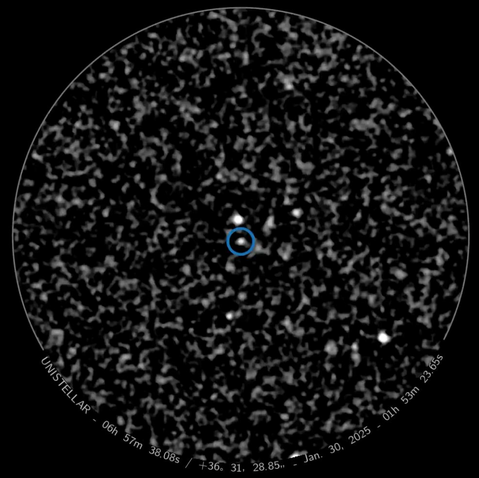
by Charles Shryock on Jan. 30, 2025

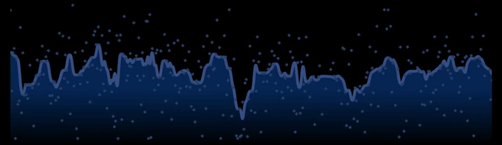


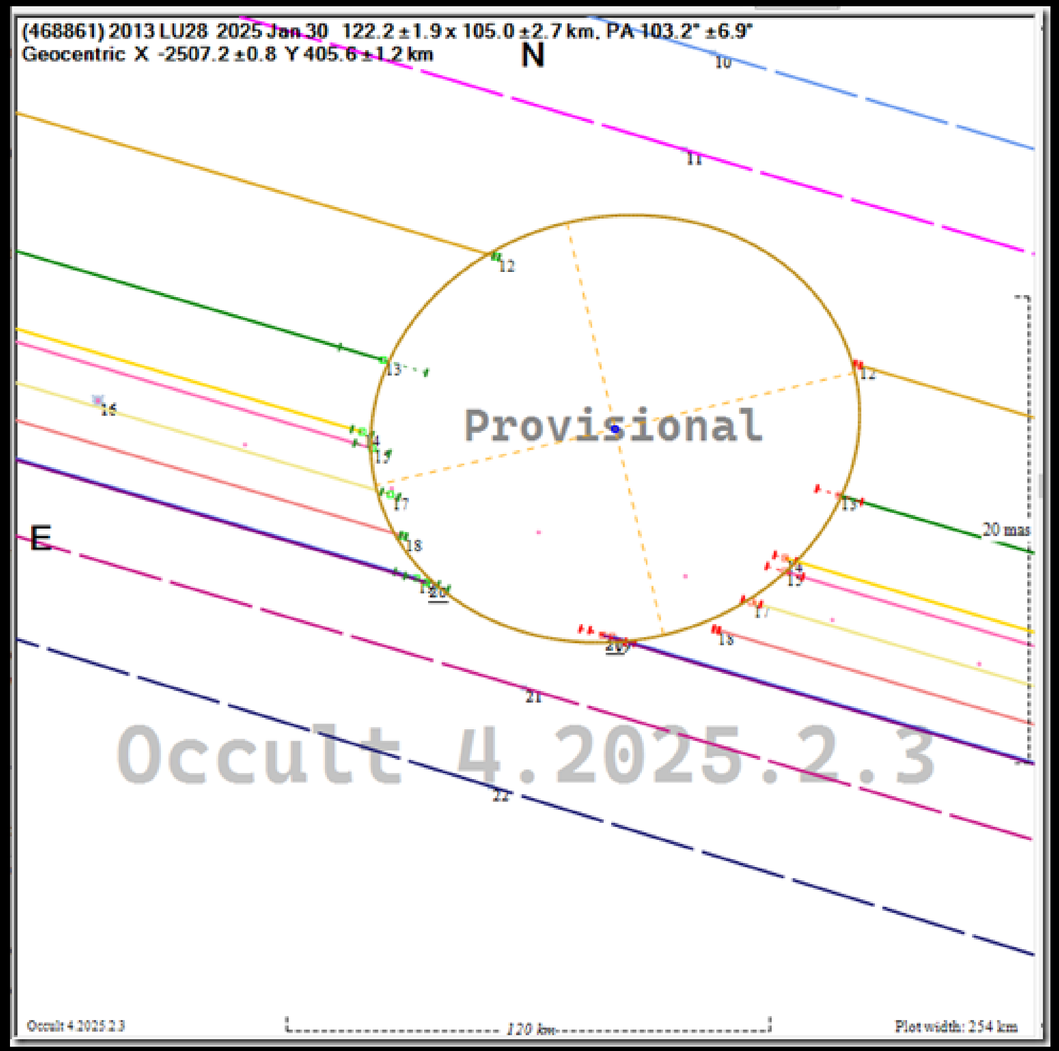


Occultation by (468861) 2013 LU28

by Ivan Venzor on Jan. 30, 2025

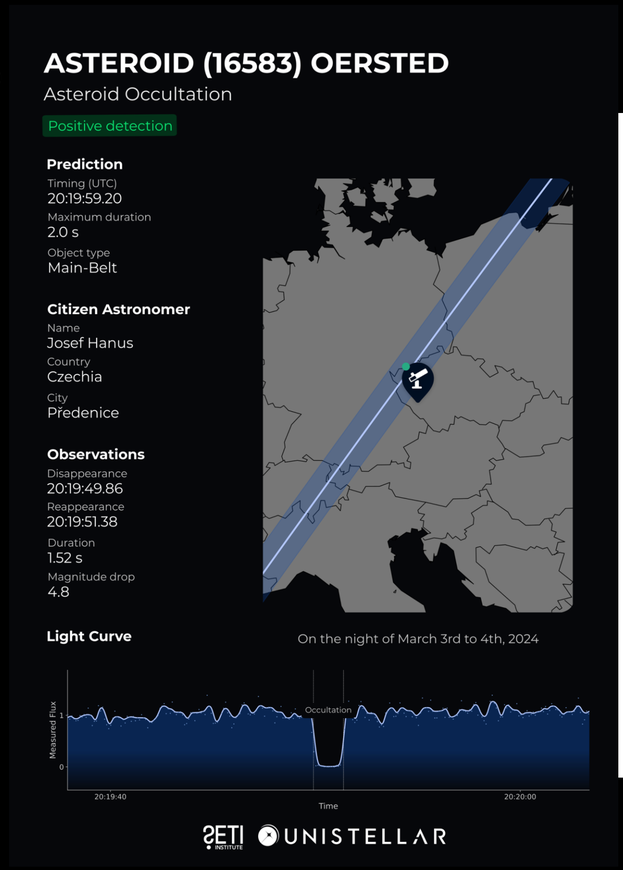


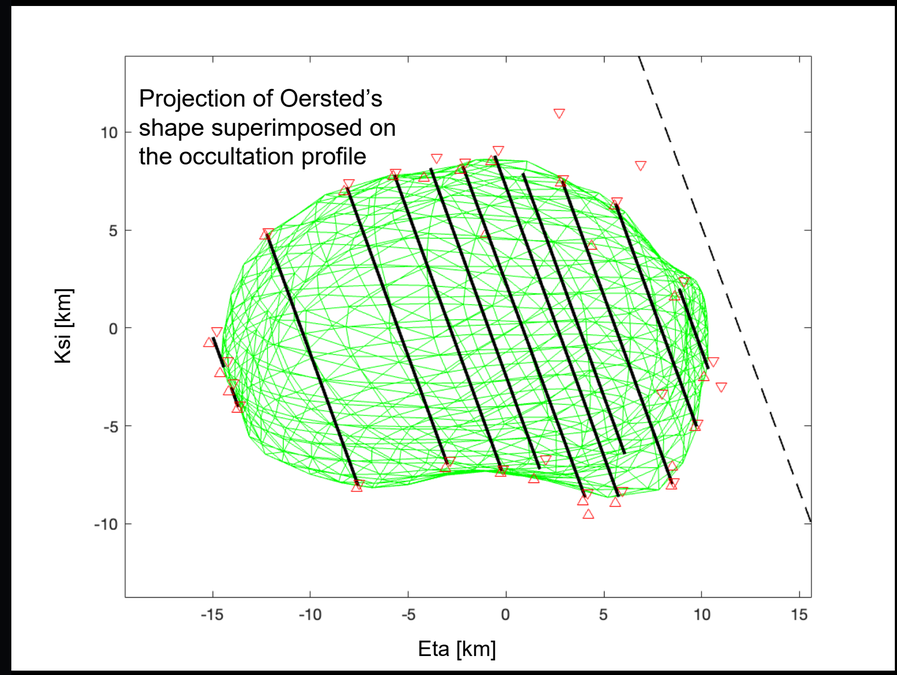


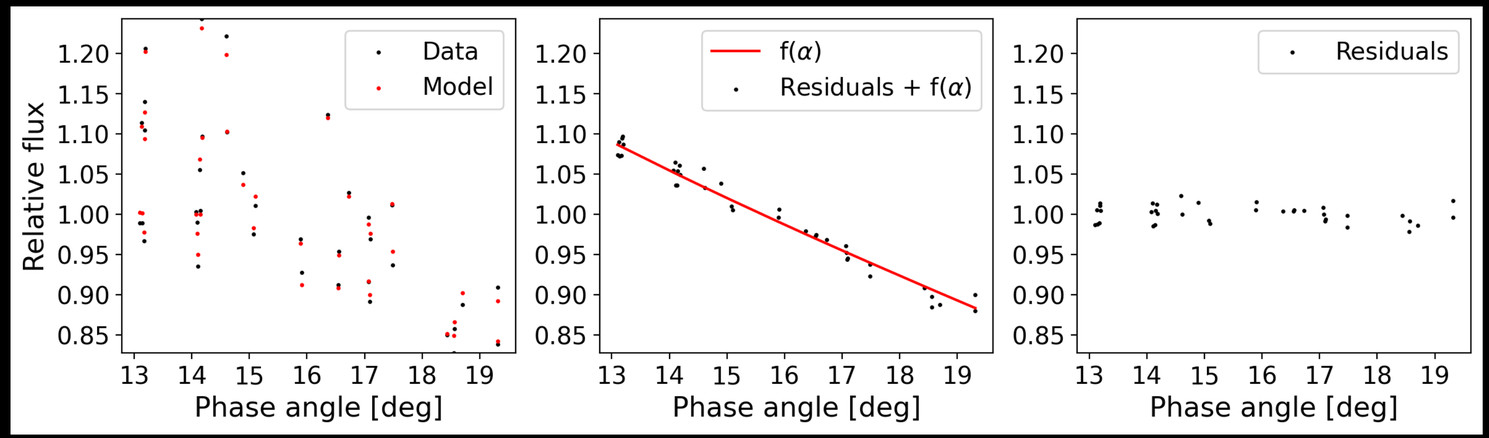


Occultations

- (16583) Oersted – example of a multi-chord event with our small contribution
  - This is what we aim for
  - Small MBA that is poorly characterized
  - 14 stations, 13 positive detections, one is a grazing and one a miss, one eVscope, most observers are from Czechia, two from Latvia
  - We used the profile, together with the available photometry, for the shape optimization and size determination (ADAM algorithm, Viikinkoski et al. 2015)
  - First spin state and shape solution for Oersted, reliable size estimate (Hanuš et al., submitted to A&A)
  - Shape model will be available in DAMIT database
  - Bottom figure depicts the fit to the photometry from Gaia DR3

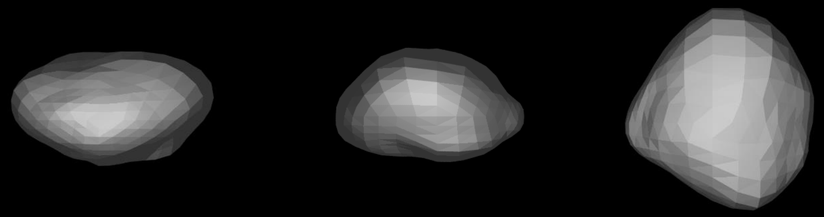


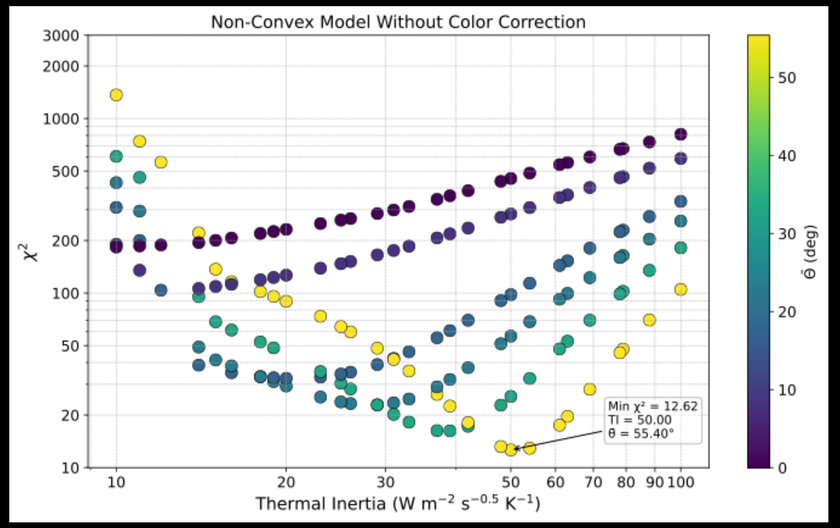


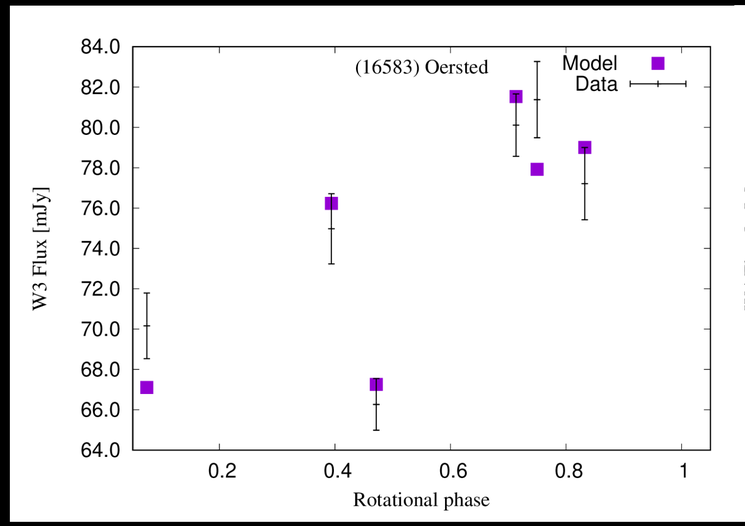


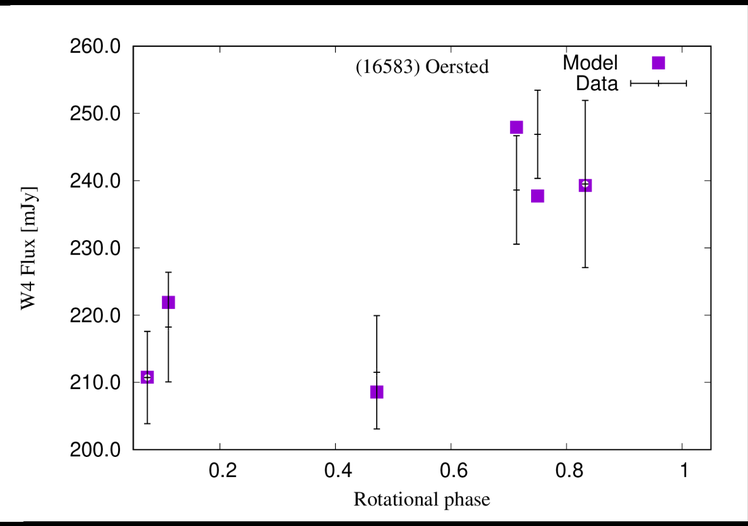
Occultations

- (16583) Oersted – example of a multi-chord event
  - But even more can be done…
  - We also used the shape model and WISE thermal infrared data to constrain thermophysical properties by the thermophysical model
  - Upper figure – shape model from front, side and top
  - Middle figure depicts the thermophysical model fit to the WISE infrared fluxes, thermal inertia
  - Bottom figure – fit to the WISE thermal infrared data in rotation phase









Occultations

- (342842) 2008YB3
  - A centaur with a large prediction uncertainty, on retrograde orbit
  - July 28th, 11 mag star, max duration 2s
  - Many observers in the path -> 7 observations
  - All negative, bad luck…
  - 4 stations on OWC – but no observation
  - Upper figure – shadow path with its uncertainty

ASTEROID (342842) 2008 YB3

On the night of July 27th to 28th, 2025

Prediction

Timing (UTC)
04:21:16.23

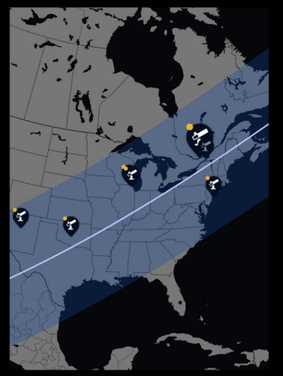
Maximum Duration
2.12 s

Object type
Centaur

Citizen Scientist

Name
Georges Simard

Location
Canada



Observations

Disappearance (UTC)
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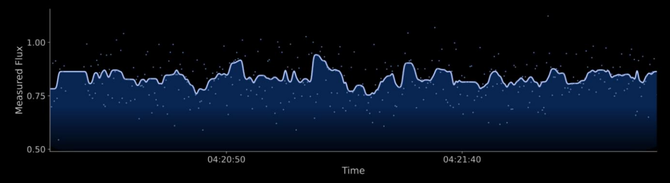
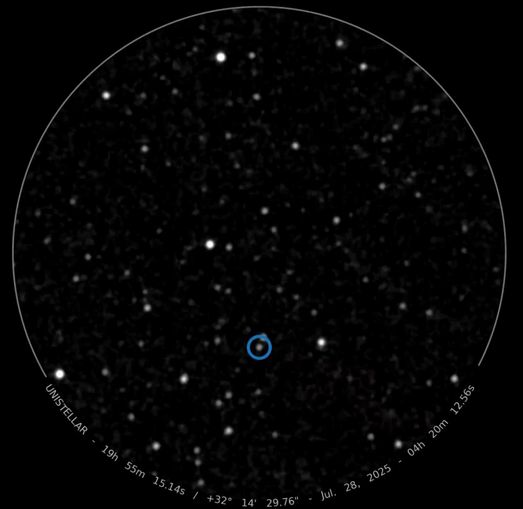
Reappearance (UTC)

Light Curve



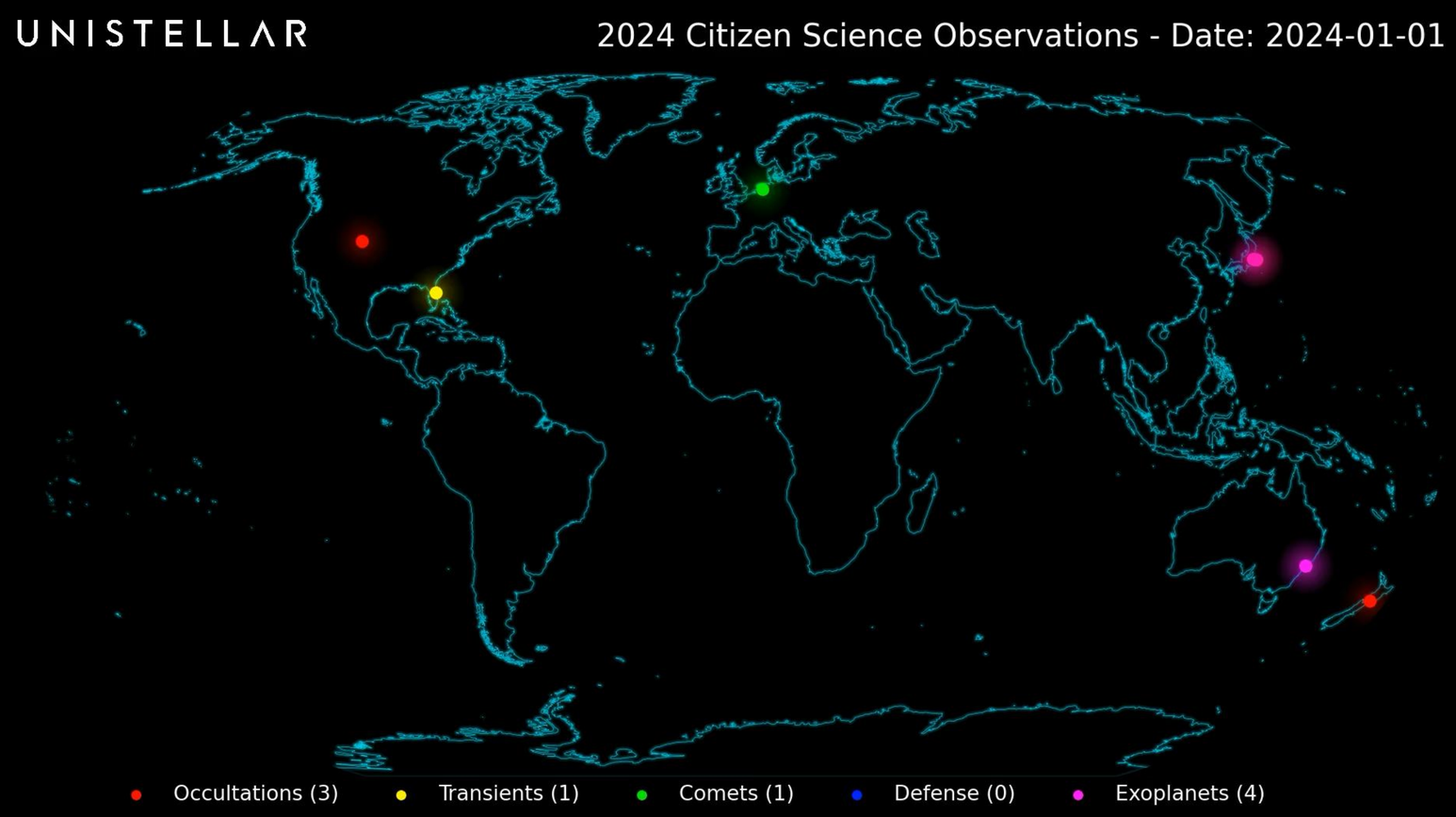
Occultation by (342842) 2008 YB3

by Georges Simard on Jul. 28, 2025



Summary

- Unistellar network is the largest community of potential citizen astronomers (>15,000)
- Several types of scientific observations are supported
- We focus on physical characterization of asteroids via optical photometry and stellar occultations
- Stellar occultations represent a direct method for size determination
- The aim is to obtain multi-chord observations, which help to refine the shape as well (cf. Oersted)
- We allow non-scientists to contribute to science, some ppl take it seriously, got independent on us
- Tool for popularization of astronomy



What will come next?

SkyMapper.io – a decentralized network of telescopes, connected via SkyBridge

SKYMAPPER

- Harness the collective power of a global telescope network, initially consisting of eVscopes
- Do observations remotely with telescopes conveniently located – in the path of the occultation, different time-zone, latitude, darker sky, etc.
- Prediction – fully remote multichord occultation observations with the network by the end of 2025, first occultation observation in September

Citizen Science Growth