Stellar Occultation by Jupiter's Irregular Moon **Kallichore**

Observer Information and Practical Guidelines
(12 April 2026 – Southwestern France)

Yücel Kılıç, Jose Luis Ortiz, Juan Luis Rizos

on behalf of the Kallichore Occultation Collaboration

Instituto de Astrofísica de Andalucía (IAA-CSIC), Granada, Spain
Email: `ykilic@iaa.es`

Document last updated on March 29, 2026

Abstract

This document provides practical observing guidelines for the upcoming stellar occultation by Jupiter's irregular moon *Kallichore*. It is aimed at both professional and amateur astronomers and focuses on observational strategy, technical requirements, timing accuracy, and data submission through the Occultation Portal (https://occultationportal.org).

Contents

1 Overview of the Event

During the night of **12 April 2026**, at approximately **00:07:14 UT** (subject to refinement and dependent on site coordinates), a stellar occultation by **Kallichore**, one of Jupiter's irregular satellites, is predicted to occur. The shadow path is expected to cross **France from the Atlantic coast near Bordeaux, passing north of Toulouse and south of Montpellier, and continuing toward the Mediterranean near Marseille**, with additional observing opportunities in nearby regions. Along much of the path, the target altitude is only about **10° above the horizon**, which makes observations challenging despite the bright occulted star.

Key aspects of the event:

- Occulting body: Jupiter irregular satellite **Kallichore** (~3.8 km in diameter).
- Occulted star: $V = 12.49$, $G_{\text{Gaia}} = 11.90$.
- Maximum occultation duration: ~**0.24 s**.
- High time resolution is important: frame times of ≤ 0.05 **s** are strongly recommended (≤ 0.1 **s** minimum target). If technical constraints force slower sampling, observations with frame times up to ~**1 s** are still encouraged, although with reduced temporal precision.
- Recent high-precision astrometry from the **Hubble Space Telescope (HST)**, combined with constraints from a recent **positive single-chord occultation**, has reduced the current path uncertainty to roughly **12 km along-track** and **14 km cross-track** (1σ), with further refinements expected as additional data are incorporated.

A standalone interactive HTML map of the predicted shadow path is available at: interactive prediction map.

Observers are encouraged to check the event page on Occult Watcher Cloud (OWC) to review event details and ensure that their observing sites do not overlap with other planned stations.

Observer registration, and submission of observing reports can be performed through the *Occultation Portal*:

—> https://occultationportal.org/create_report/2967/

2 Scientific Motivation

Kallichore is a very small (~2–5 km) irregular satellite of Jupiter and a strong candidate for a future close encounter by the **ESA JUICE mission**. Although JUICE primarily targets the Galilean satellites, small irregular moons such as Kallichore are scientifically compelling, as they may be captured **trans-Neptunian objects (TNOs)** originating from the early dynamical instability phase of the Solar System.

Stellar occultations have proven to be a powerful and often essential tool for mission planning and science return, as demonstrated for **(486958) Arrokoth** prior to the **NASA New Horizons** flyby (Buie et al. 2020). Similarly, the **NASA Lucy** mission has implemented an extensive occultation program for its small-body targets. In this context, detecting and characterizing an occultation by Kallichore is of exceptional interest: if confirmed as a captured TNO, it would represent the **smallest trans-Neptunian object ever probed through a stellar occultation**.

A major milestone was reached on **15 December 2025**, when a **single-chord occultation** by Kallichore was successfully detected. This result relied on a coordinated effort, including high-precision pre-event astrometry from the **Hubble Space Telescope (HST)**. Subsequent analysis revealed several additional occultation opportunities, making it essential to obtain a new detection before the orbit solution degrades.

Thanks to the combination of the successful occultation, HST astrometry, and recent **10-m class GTC imaging**, the current predictions have reached high accuracy. The most promising upcoming event occurs in **April 2026**, with a shadow path crossing **France from the Atlantic coast near Bordeaux, passing north of Toulouse and south of Montpellier, and continuing toward the Mediterranean near Marseille**, with additional observing opportunities in nearby regions. The occulted star is relatively bright ($V = 12.49$, $G_{\text{Gaia}} = 11.90$), but the low altitude (around 10°) and short duration (~0.24 s) make this event technically demanding and highly valuable for a coordinated professional–amateur campaign.

The primary goal is to progress from a single-chord detection to a **multi-chord occultation**. Observations from three or more sites would allow us to constrain the **size, shape, albedo, and position** of Kallichore with much higher precision, potentially leading to a high-impact result well before the planned **JUICE flyby in 2031**.

3 Event Details

Important: All numerical values (times, path width, etc.) are subject to refinement as new observations, including additional HST astrometry, are incorporated. Observers are strongly encouraged to check the latest information on the Occultation Portal shortly before the event.

Low-altitude warning: The event geometry places the target at roughly **10° altitude** for many sites on the path. A clear and unobstructed horizon is essential, and observers should test acquisition and tracking under similar low-elevation conditions before event night.

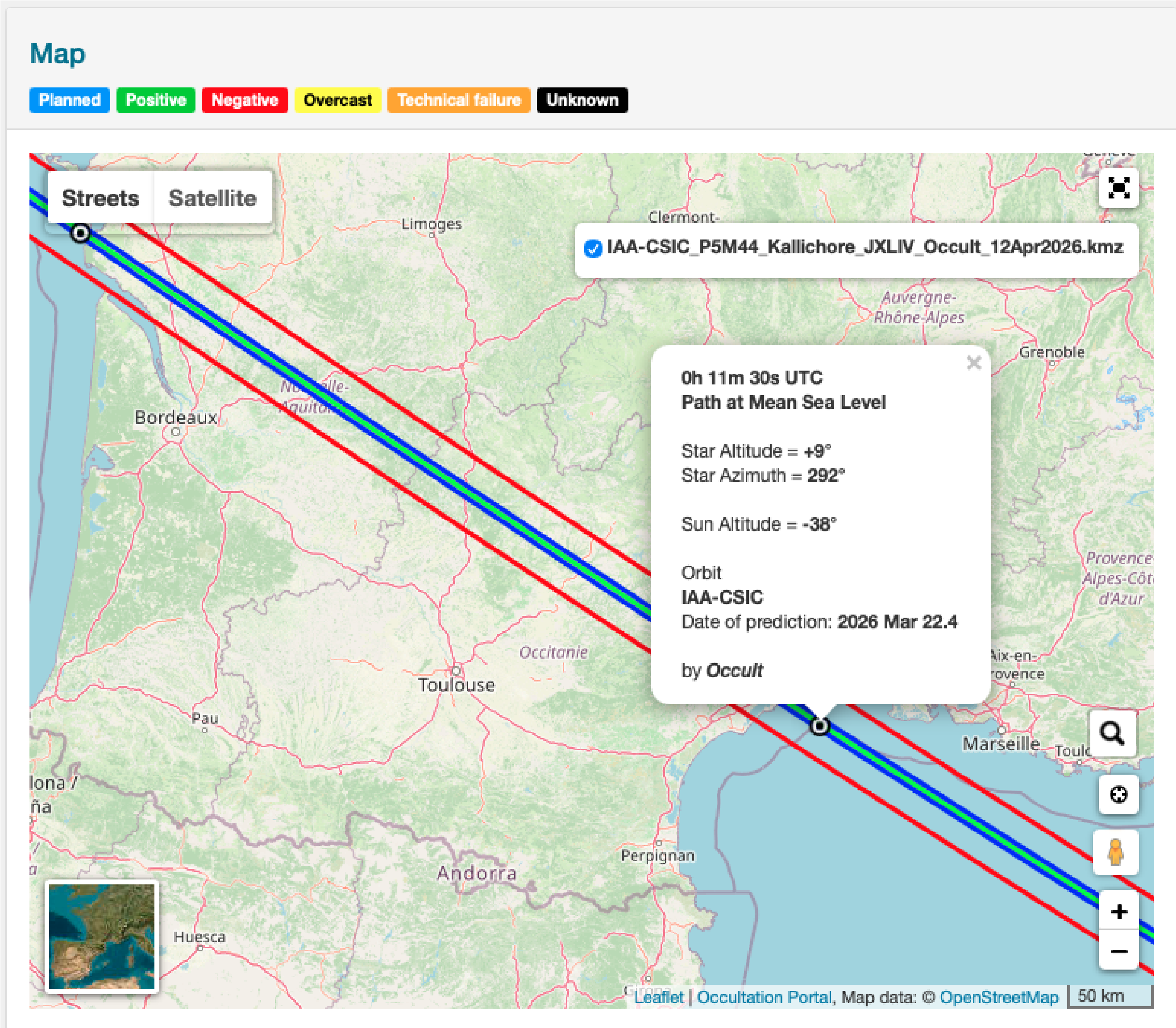

Figure 1: The **green line** represents the nominal centreline of the predicted shadow path derived from the latest astrometric solution. The **blue lines** indicate the limits corresponding to the best-estimated projected diameter of the object. The **red lines** show the current 1σ **cross-track uncertainty** of the predicted shadow path. Blue markers along the path indicate reference locations for the event. Clicking on a marker displays a pop-up panel with the local circumstances of the occultation, including the predicted event time, the altitude and azimuth of the target object, and the altitude of the Sun and Moon.

Quantity	Value / Comment
Nominal occultation time (UTC)	00:07:14 UT (12 April 2026)
Occulting body	Jupiter irregular satellite **Kallichore** ($\sim$3.8 km)
Occulted star (UCAC4 / Gaia DR3)	UCAC4 561-040971 / Gaia DR3 3367207940057486464
Star coordinates (ICRS @ event)	RA = 07:17:17.61797593, Dec = +22:09:09.60358065
Star magnitude	$V = 12.49$, $G_{\text{Gaia}} = 11.90$
Expected magnitude drop (R band)	11.01 mag
Maximum duration	$\sim$0.24 s
Shadow-plane velocity	15.90 km s^{-1}
1σ path uncertainty	$\sigma_{\text{along}} \simeq 12.13$ km, $\sigma_{\text{cross}} \simeq 14.14$ km
Moon conditions	0.3% illumination, angular separation $\sim$155.6°
Predictions and maps	Updated on the Occultation Portal
Occultation Portal event URL	https://occultationportal.org/create_report/2967/

Table 1: Summary of the main event parameters (subject to refinement as new astrometry becomes available).

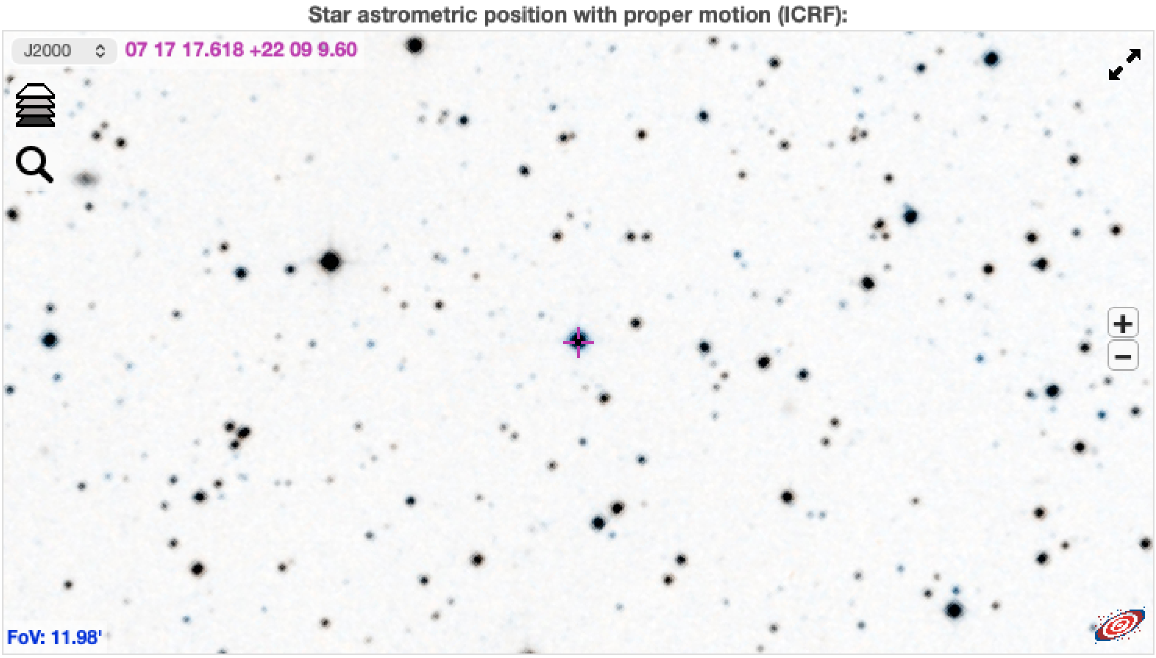

Figure 2: Sky chart showing the position of the target star at the time of the occultation, including nearby reference stars. Field of view: **11.98' × 11.98'**. An interactive version of this sky view is available at AladinLite Sky View, and on the Occultation Portal.

4 Weather Considerations

Accurate weather assessment is critical for the success of a stellar occultation observation, particularly for short-duration events such as this one. For the **12 April 2026** Kallichore occultation, weather monitoring should focus on the corridor from the **Atlantic coast near Bordeaux**, **north of Toulouse** and **south of Montpellier**, toward the **Mediterranean near Marseille**, as well as nearby regions. In this period of spring, local cloud variability and low-elevation haze can strongly affect detectability, especially because the target altitude is close to **10°**.

4.1 Seasonal and Monthly Outlook

For medium-term planning and last-minute optimisation of observing sites, observers are strongly encouraged to consult **Météo-France** products together with European forecast models.

The following services provide regularly updated **seasonal and monthly outlooks**:

- **Météo-France – Climate and seasonal outlooks**
  https://meteofrance.com/climat
- **Copernicus Climate Change Service (Europe-wide products)**
  https://climate.copernicus.eu/

4.2 Short-Term Forecasts and Nowcasting

In addition to seasonal outlooks, short-term forecasts and real-time monitoring are essential in the final days leading up to the event. We recommend consulting multiple independent forecast services:

- **Meteoblue (global high–resolution forecasts)**
  https://www.meteoblue.com/
- **Météo-France**
  Official forecasts, radar and warnings for metropolitan France
  https://meteofrance.com/
- **Météo-France AROME model products**
  High-resolution short-term forecasts suitable for site-level decisions
  https://meteofrance.com/previsions-meteo-france
- **YR (Norwegian Meteorological Institute)**
  https://www.yr.no/
- **Windy (cloud cover, wind, satellite imagery)**
  https://www.windy.com/

- **AEMET and neighbouring services (cross-border context)**
  https://www.aemet.es/
- **Real-time satellite cloud imagery**
  https://www.sat24.com/

4.3 Practical Recommendations

For best results, observers are advised to:

- Rehearsal one or several days before the event is recommended; if you are new to occultation work, rehearsal is essential.
- Check weather forecasts **24 hours**, **6 hours**, and **1–2 hours** before the predicted occultation time.
- Identify at least one **backup observing site** within reasonable driving distance.
- Use animated satellite imagery (e.g. via Windy or Sat24) to assess cloud motion and identify potential clear-sky windows.
- Remain flexible in site selection, especially in the final 12–24 hours before the event.
- Prefer sites with a clean horizon toward the occultation azimuth; low-altitude extinction and haze can dominate the error budget.

Careful use of both seasonal outlooks and real-time monitoring can significantly increase the probability of a successful observation.

5 If You Are Observing with a Telescope

If you have access to a telescope and a camera, you are already in a strong position to contribute.

General guidelines:

- A telescope aperture of $\gtrsim$15–20 cm is generally sufficient for a $G_{\text{Gaia}} \simeq 11.90$ star ($V \simeq 12.49$) at high cadence; however, because the target is very low, apertures of 20–30 cm are preferred to mitigate extinction and scintillation. Dark locations are not mandatory, but avoiding bright local horizons is important (see https://www.lightpollutionmap.info).
- Standard sidereal tracking is sufficient; accurate guiding is helpful but not strictly required if the field stays stable.

The main goal is to obtain a continuous time series around the event with:

- **Time resolution** ≤ 0.1 s (preferably 0.02–0.05 s if SNR allows), but integrations up to 1s can be acceptable.
- **SNR** ≥ 5 per frame on the target star,
- At least **5 minutes** of data before and after the predicted event time.

6 If You Have a Fast Camera

Here, a "fast camera" refers to a CMOS or CCD video-type detector capable of frame rates $\gtrsim$10–20 frames/s with negligible or very small dead time.

6.1 Frame Rate and Exposure Time

Aim for the highest feasible frame rate while maintaining SNR ≥ 5 per frame. As a practical rule of thumb:

- 10 fps $\Rightarrow$ frame time = 0.10 s, use an exposure time of about 0.09 s,
- 20 fps $\Rightarrow$ frame time = 0.05 s, use an exposure time of about 0.045–0.05 s,
- 50 fps $\Rightarrow$ frame time = 0.02 s, use an exposure time of about 0.018–0.02 s.

Exposure times should never exceed the frame time (1 / fps). In practice, keeping the exposure slightly below this limit leaves room for readout and helps to avoid any dead time between frames.

If SNR is too low, increase exposure time (thus lowering frame rate) until you reach SNR ≥ 5.

6.2 ROI and Binning

- Use **binning** and/or a **small region of interest (ROI)** to increase frame rate and reduce read noise.
- Include the target star and, if possible, at least one or two **comparison stars** in the same field for differential photometry.

7 If You Do Not Have a Fast Camera

If your detector has slow readout (e.g. many classical amateur CCD cameras) and cannot reach high frame rates, consider the following options.

7.1 Standard Time-Series Photometry

If you can reach exposure times of $\sim$0.5–1 s with SNR ≥ 5 on the target star:

- Your data can still be valuable to constrain non-detections, half-chords or grazing events.
- The light curve will be temporally "smeared", since the true event duration ($\sim$0.24 s) is shorter than your exposure. However, this still imposes constraints on the chord geometry and event timing.

7.2 Drift-Scan (Advanced / Optional)

With slow CCD cameras one can use the **drift-scan** mode (tracking turned off so the star trails along the detector while the shutter remains open). Time is then encoded along the trail.

- This method is technically demanding and requires careful calibration. Tests or rehearsal should be done before the occultation.
- It is recommended only for observers already experienced in drift-scanning.

8 If You Do Not Have a Dedicated Astronomical Camera

A dedicated astronomical camera is strongly recommended, but if you do not have one:

- You may adapt a **planetary camera** or even a high-quality **webcam** to your telescope, provided it can reach sufficient frame rates and you can save data in minimally compressed formats.
- Laptop + inexpensive USB CMOS planetary cameras can often achieve $\geq$20 fps on a $\sim$12.5 mag star with adequate aperture under transparent skies.
- Whenever possible, record in **SER** or **FITS** formats rather than heavily compressed video codecs.

9 If You Have More Than One Camera

If you have multiple instruments at your disposal:

- Prefer the setup that offers the **highest frame rate with negligible dead time**, while maintaining SNR ≥ 5.
- A recommended strategy is:
  - One high-speed system optimised for **time resolution**.
  - A second system (if available) optimised for **higher SNR** (slightly longer exposures, possibly a different filter) as a backup and for cross-checks.
- Two independent systems observing from the same site are extremely valuable to identify possible instrumental artefacts.

10 Filters and Photometric Considerations

For this event, the occulted star has magnitudes approximately $G_{\text{Gaia}} \simeq 11.90$ ($V \simeq 12.49$) and the expected maximum duration is only $\sim$0.24 s. Therefore, the highest priority is to maximise the **signal-to-noise ratio (SNR)** per frame.

Observers are strongly encouraged to observe *without any filter* (clear / no-filter mode).

- Using no filter significantly increases photon flux and improves SNR.
- This is essential for achieving the recommended time resolution ($\leq$**0.1 s per frame**) while keeping **SNR $\geq$ 5**.
- For CMOS video cameras, "L" (luminance) or "clear" settings are appropriate.

If, for technical reasons, you must use a filter (e.g. optical system constraints or severe light pollution), then:

- Use the **broadest and brightest** passband available (e.g. luminance or wide-open clear glass).
- Avoid narrowband filters entirely (Hα, SII, OIII), as they will reduce the SNR too much for this event.

In all cases, the guiding principle is:

Maximise photon flux → maximise SNR → maximise detection probability.

11 If You Do Not Have a Telescope

If you do not own a telescope but have:

- A **DSLR or mirrorless camera** with a lens of $\gtrsim$200–300 mm focal length, or
- A small telephoto lens (e.g. 400–600 mm) on a tracking mount,

you may still attempt high-speed imaging:

- Use video mode or rapid continuous stills, pushing ISO as high as necessary while still keeping noise manageable.
- Aim for exposures approaching the time-resolution requirement ($\leq$0.1 s), at least near the predicted event time.
- Test your setup beforehand on a star of similar brightness.

12 General Notes on Cameras and Filters

- Monochrome cameras with R/V/B filters are ideal; however, colour cameras are also acceptable and individual colour channels can be analysed separately.
- Recommended recording formats:
  - **SER** video files, or
  - **FITS** image sequences.
- If you use capture software such as **SharpCap**, select SER or FITS as the recording format and avoid strong compression.

13 Computer Time Synchronisation

Accurate timing is critical for stellar occultation studies.

13.1 Windows Systems

On Windows machines, you can use time-synchronisation tools such as:

- Dimension 4,
- Meinberg NTP.

General recommendations:

1. Install the software and choose a reliable NTP server (e.g. national metrology institute, well-known public NTP server).
2. Configure regular synchronisation (e.g. every few minutes before and during the observing session).
3. Check that the reported time offset remains well below $\pm$0.05 s if possible.

13.2 GNU/Linux Systems

On GNU/Linux systems:

- Use `ntpdate`, `chrony` or a similar NTP client to synchronise your system clock with a trusted server.
- Ensure that your system stays synchronised throughout the whole observing session.

13.3 GPS-Based Solutions

If you have access to a **GPS-based time inserter** or a camera with built-in GPS time stamping:

- Prefer hardware GPS timestamps whenever possible.
- Document how the timestamps are generated and how they relate to UT.

14 Example Observing Configuration

As a practical reference for observers preparing their equipment, the following configuration was successfully tested on a target of comparable brightness and similarly challenging low-altitude geometry.

Telescope: Meade LX200, 30 cm aperture, operating at f/5
Camera: Watec WAT-910BD+ with IOTA-VTI time inserter
Camera settings:

- Integration: 2F (∼0.08 s cadence)
- Gain: 41 dB

With this configuration the target star was clearly detectable in individual frames at a cadence of 0.08 s. This provides a useful balance between time resolution and signal-to-noise for this Kallichore occultation.

Observers using smaller apertures may consider slightly longer integrations (e.g. 4F ∼0.16 s) if necessary to improve the signal-to-noise ratio, especially at low target altitude.

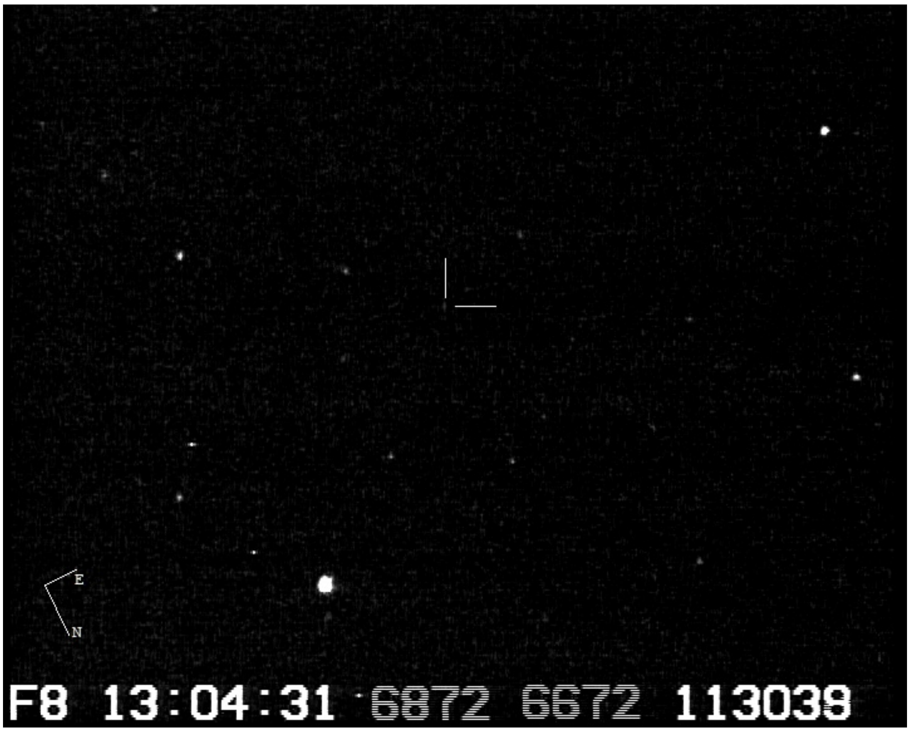

Figure 3: Test image of the Kallichore target star obtained using a 30 cm telescope and Watec WAT-910BD+ camera with a cadence of 0.08 s (2F). The target star is clearly detectable under similar observing conditions to those expected during the occultation night.

15 Data Upload and Coordination

After acquiring your data:

1. **Do not delete any raw data.** Keep all SER/FITS files and related logs.

2. Contact your local or regional coordinator if applicable.
3. Upload your data and observation details to the **Occultation Portal**:
    - Event page (registration and report submission): https://occultationportal.org/create_report/2967/

On the Occultation Portal you will find:

- A fully zoomable, high-resolution shadow-path map.
- Up-to-date prediction refinements, including those based on new HST astrometry.
- Tools to register your site, instrument and observation details.

It is essential that all observers register and submit their data through the Portal, so that:

- Global coverage can be coordinated efficiently.
- Your contribution can be properly acknowledged in future scientific publications.

16 General Observing Notes

- Ensure that you have sufficient disk space and memory to record several minutes of data at your chosen frame rate.
- Verify the geographical coordinates and altitude of your observing site using GPS and/or services such as Google Maps or Google Earth.
- Include comparison stars in the field if possible, to enable differential photometry.
- Record from at least **5 minutes before** until **5 minutes after** the predicted event time.
- If the sky is partly cloudy, short clear intervals can still yield useful data; do not give up prematurely.
- Whenever possible, perform test runs on previous nights on stars of similar magnitude to optimise exposure time, gain and frame rate.

17 Participating Without Any Equipment

For this event, with a relatively bright star ($V \simeq 12.49$, $G_{\mathrm{Gaia}} \simeq 11.90$) and a very short duration ($\sim$0.24 s), scientific contribution without recording equipment is limited.

However:

- You can still support the campaign by helping with local logistics, hosting observers, or coordinating with nearby astronomy groups.
- You may also help disseminate information about the event and the campaign to local observatories, universities and amateur associations.

18 Tracking Kallichore in Stellarium (Optional Visualization)

Stellarium does not include Jupiter's irregular moon *Kallichore* in its default Solar System database. However, observers may optionally add Kallichore as a custom minor object for **visualization purposes only** (e.g. to better understand the sky context).

Important: Stellarium is not used for the scientific prediction; the official prediction map and event timing should always be taken from the **Occultation Portal**.

18.1 Enable the Solar System Editor plugin

1. Open Stellarium and press **F2** to open **Configuration**.
2. Go to **Plugins** → **Solar System Editor**.
3. Tick **Load at startup**.
4. Restart Stellarium.

18.2 Import Kallichore from a file

1. After restarting, open **Configuration (F2)** again.
2. Go to **Plugins** → **Solar System Editor** → **Configure**.
3. Choose: **"Import and add Solar System minor objects from file"**.
4. Select the provided INI file (for example `kallichore.ini`) and import it.
5. Restart Stellarium again. The new object is loaded after restart.

After the final restart, use the search box and type **Kallichore** to center it. If the object is difficult to see (it is extremely faint in reality), enable labels for Solar System objects and zoom close to Jupiter.

18.3 Kallichore INI entry

Create a text file named for example `kallichore.ini` containing the following block:

```
[kallichore]
name=Kallichore
type=moon
parent=Jupiter
iau_moon_number=JXLIV

orbit_Epoch=2461117.50080
orbit_SemiMajorAxis=23009735.816567
orbit_Eccentricity=0.335317481674
orbit_Inclination=144.403286103862
orbit_AscendingNode=167.612130818261
orbit_LongOfPericenter=320.805693970883
orbit_MeanLongitude=58.666943074738
orbit_Period=713.129409629121

absolute_magnitude=20
albedo=0.04
radius=1
tex_map=nomap.png
```

This orbit is an osculating Keplerian approximation derived from SPICE at the chosen epoch. It is sufficient for short-term visualization near the event date, but it will drift over long timescales.

19 Useful Links

- **Occult Watcher Cloud**
  https://cloud.occultwatcher.net/event/1927-P5M44-103035-649392-U040971/IAA-CSIC;GaiaDR3
- **Occultation Portal – Event and Report Page**
  https://occultationportal.org/create_report/2967/
- **Météo-France**
  Official forecasts, radar, satellite imagery, and alerts for France
  https://meteofrance.com/
- **Météo-France Climate Outlooks**
  https://meteofrance.com/climat
- **Time Synchronisation Tools**
  Dimension 4 (Windows): http://www.thinkman.com/dimension4/
  Meinberg NTP: https://www.meinbergglobal.com/english/sw/ntp.htm

20 Acknowledgements

This campaign is part of a coordinated international effort to improve the orbit of Jupiter's small irregular satellite **Kallichore**, with the broader objective of supporting the scientific return of the **ESA JUICE mission** and enabling potential future flyby opportunities.

The observational campaign and the refinement of the astrometric solution are coordinated by the **Instituto de Astrofísica de Andalucía (IAA-CSIC)**, Spain, in collaboration with an international network of professional and amateur observers.

The campaign is supported by **IAA-CSIC**, **INAF**, and **ESA**, whose involvement is essential for the successful deployment of the observing network.

We are particularly grateful to **Hristo Pavlov** for support with the Occult Watcher Cloud (OWC) infrastructure and campaign coordination tools.

We warmly thank all observers participating in this campaign, whose efforts in deploying and operating telescopes along the occultation path make this international observing effort possible.

Please feel free to redistribute this document and the official campaign emails to colleagues and local astronomy communities. **Last update:** *March 29, 2026*