

Photometric results and Next observing plan for the Flyby target Torifune

JAXA Hayabusa2# meeting

2025.10.07 22:30-23:30 (JST)

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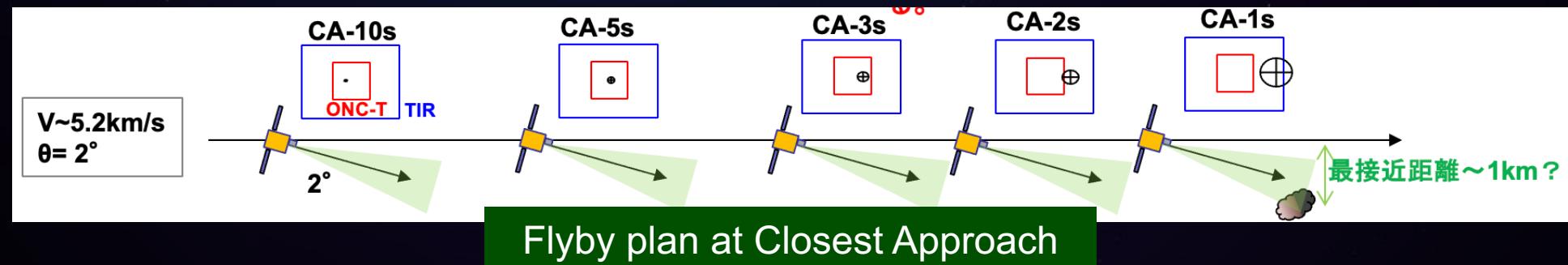
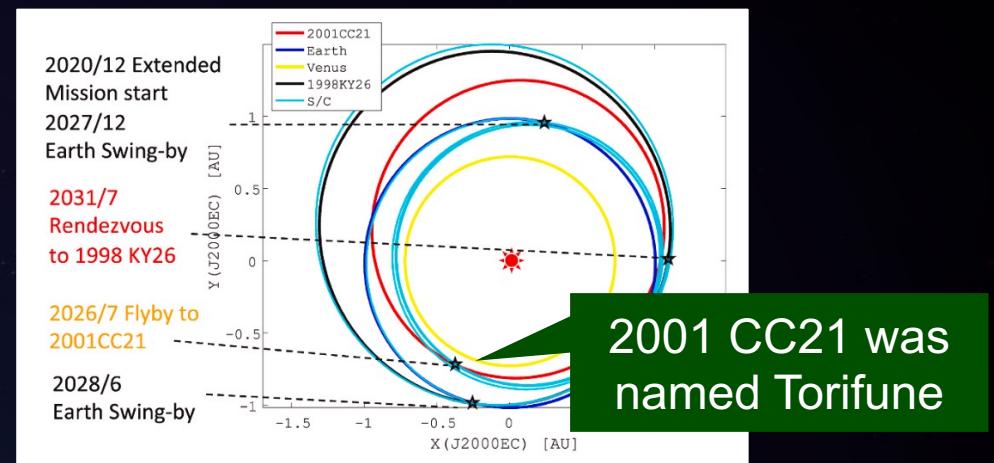
A. Goto

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1. Introduction

[Hayabusa2# Flyby at July 2026]

- Speed: ~5 km/s
- Distance: ~1 km (TBD)
- • Onboard camera is designed for the Ryugu rendezvous, **not have a zoom function**.
- Spatially resolved time is estimated to be 2-3 s, during which ~10 images are planned to be captured.
- Operations cannot be conducted during the Flyby, exposure time and gain value will be pre-set **in advance**.
- **Only the front side (one face)** of Torifune can be observed during the Flyby.



2. Ground-based observations before the Flyby

(Technical Requirement)

- Pre-setting of the onboard camera's exposure time and gain value
→**Cannot be determined without prior information of the surface color**

(Scientific Requirement)

- Surface color of Torifune (homogeneity or heterogeneity)
→**Determination of the most scientifically valuable side for Flyby observation**
→**Whether the data from the front side imaged by Hayabusa2 can represent the whole surface (Including back side) of Torifune**
- Observations using the **large-aperture Seimei telescope**, which is optimal for the faint asteroid (Torifune: ~18 absolute mag.), and with **TriCCS**, which enables simultaneous three-colors photometry un-affected by the asteroid's rotation

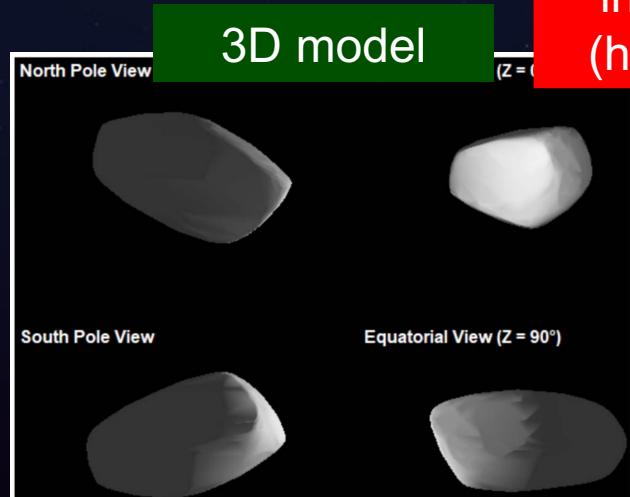
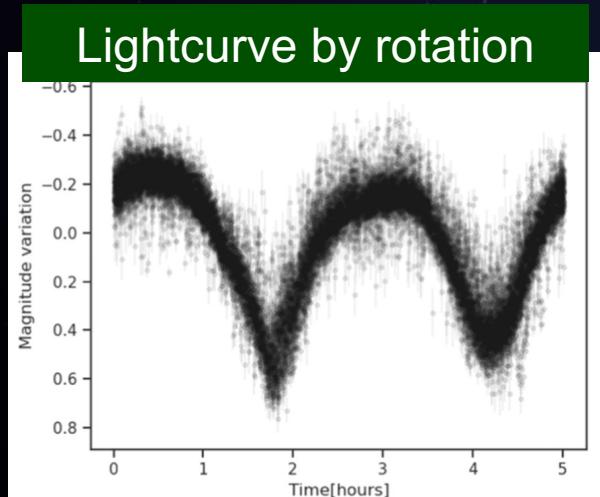
3. Previous study

(Photometry (Popescu+, 2025))

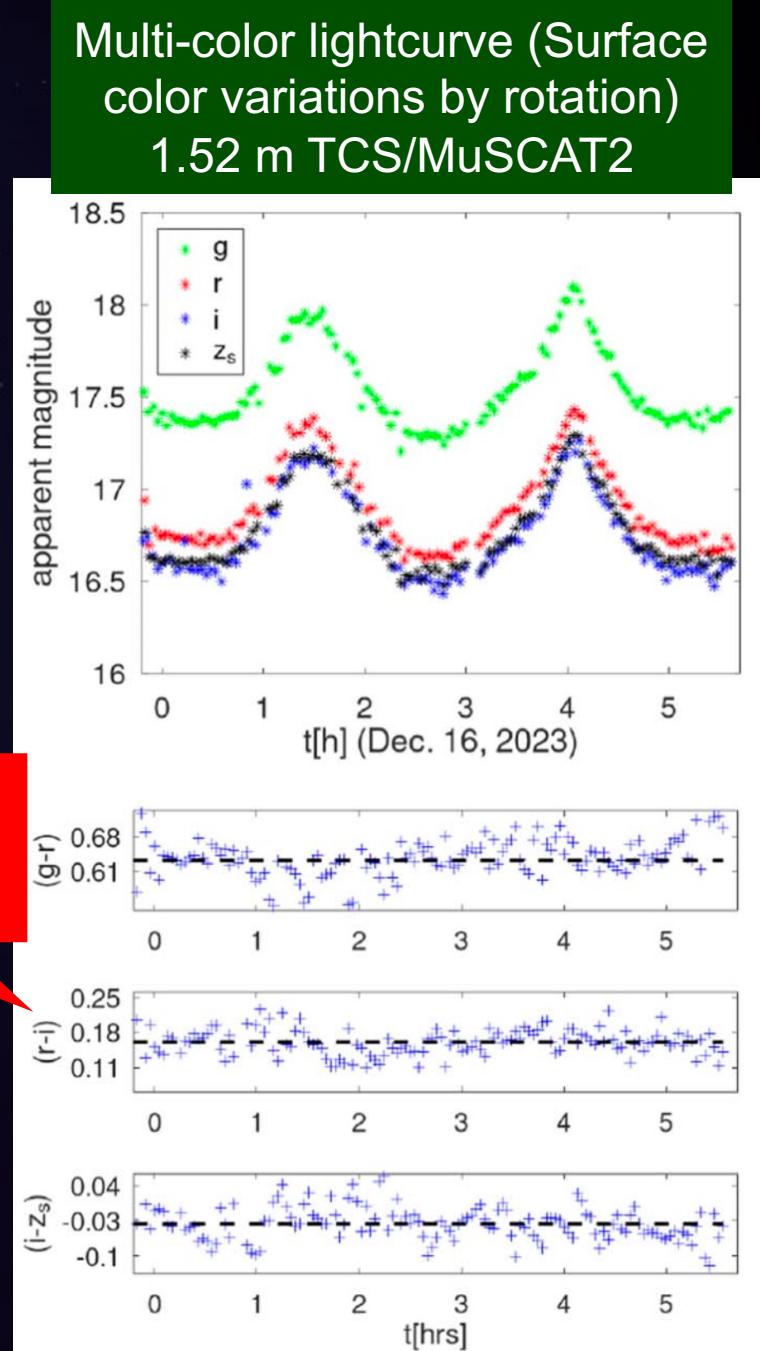
- **S-type** color index (SDSS system: $g-r$, $r-i$, $i-z_s$)
- Exhibits no large-scale heterogeneity (**surface homogeneity**)

(Lightcurve (Popescu+, 2025; Fatka+, 2025 etc.))

- **Rot. period: 5.02 h**
- Shape



Small variations
in color index
(homogeneity)

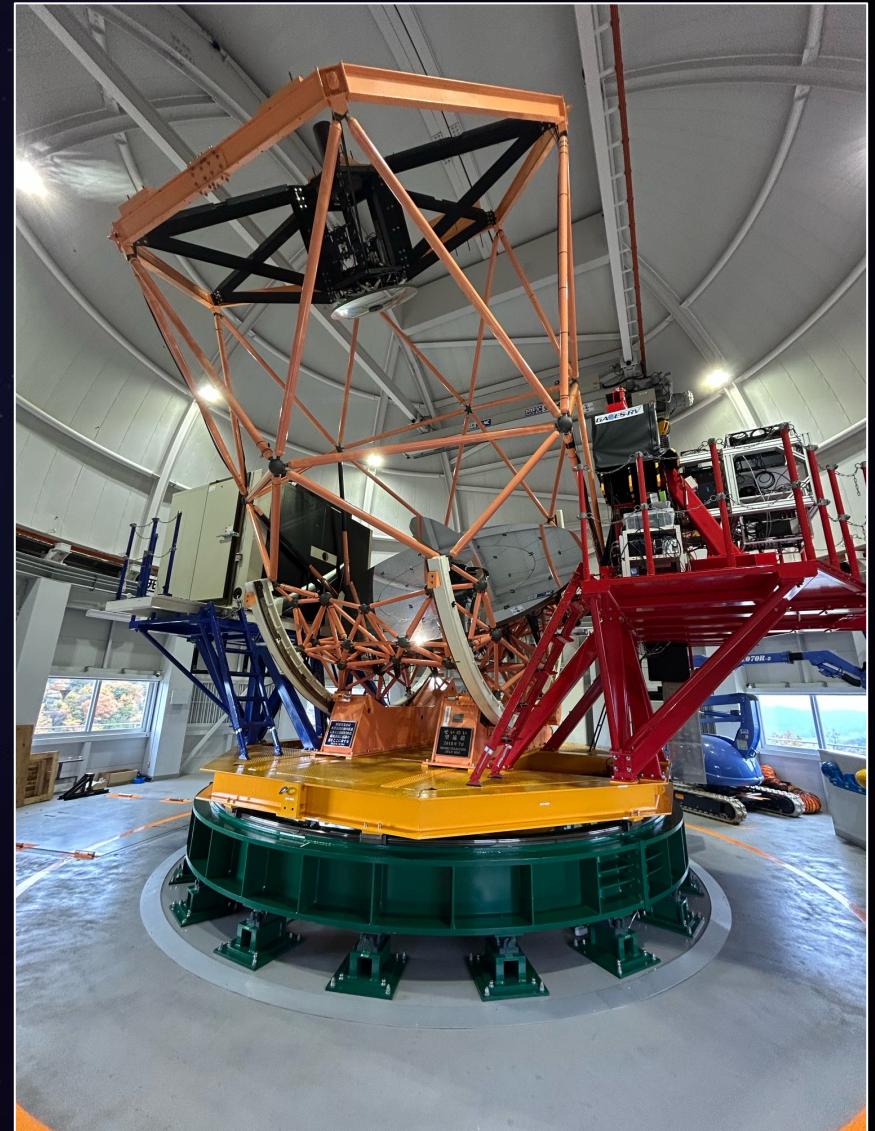


4. 3.8 m Seimei / TriCCS

【3.8 m Seimei telescope】

- Location: Okayama observatory, Japan
- Own: Kyoto Univ., and open use by NAOJ
(National Astronomical Observatory of Japan)

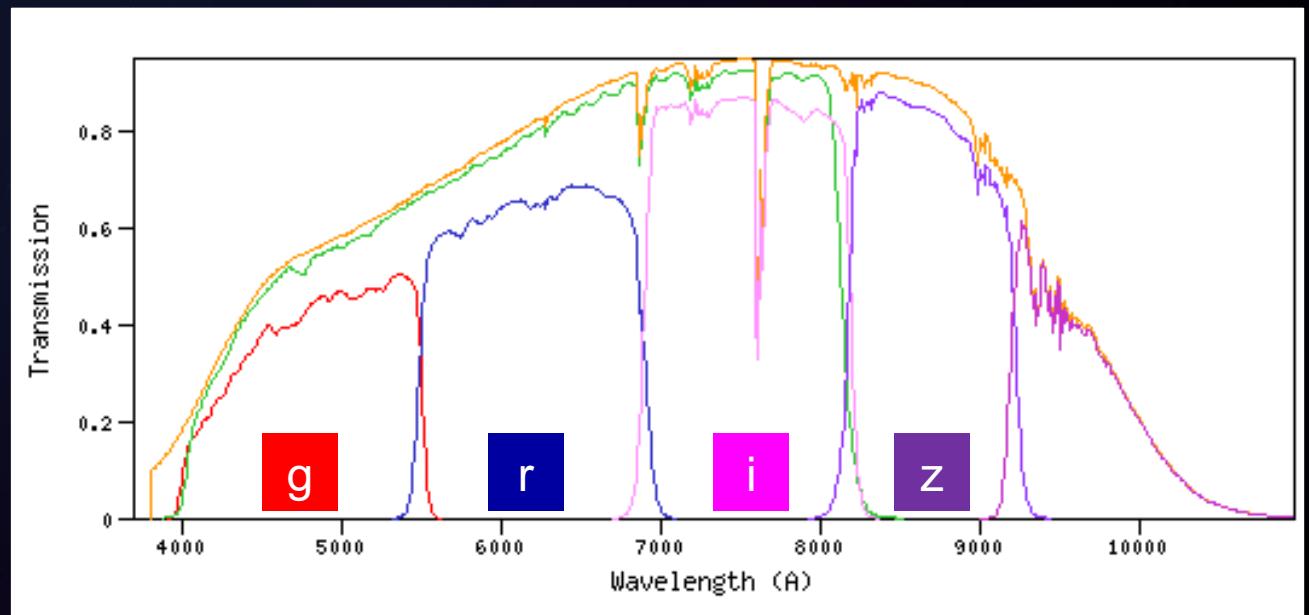
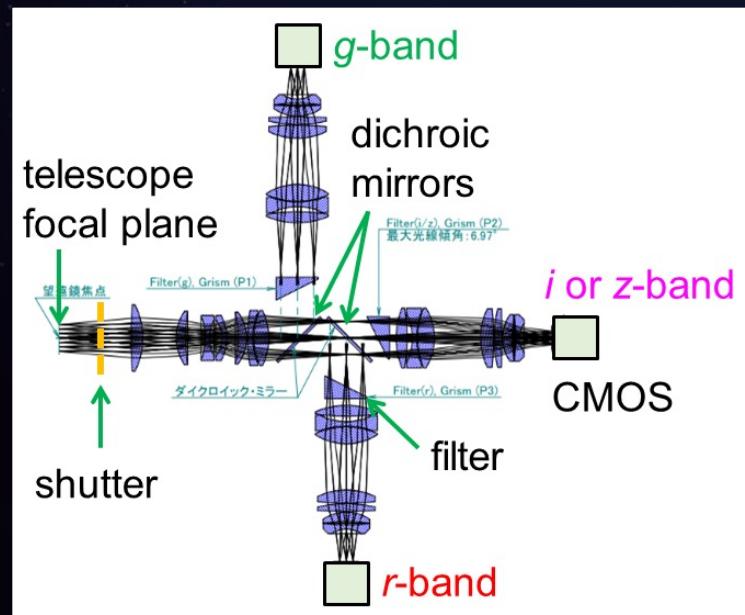
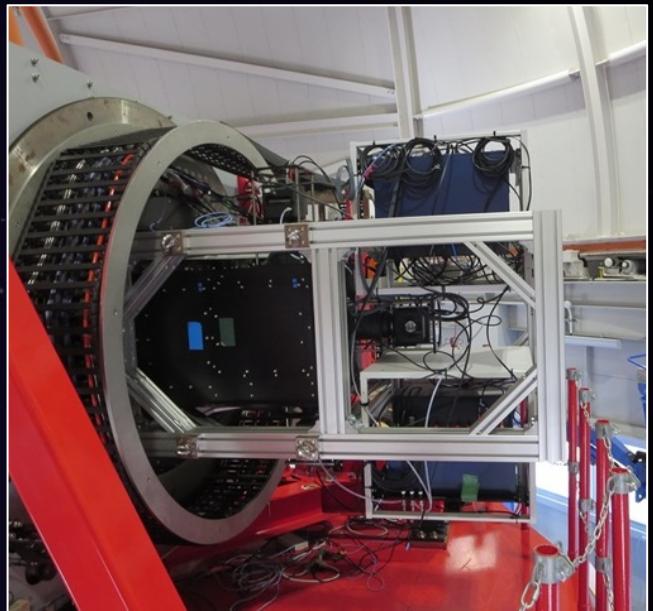
→The **largest optical telescope** in East Asia



4. 3.8 m Seimei / TriCCS

【TriCCS (Tricolor CMOS Cameras)】

- Imaging mode: Three-colors simultaneous photometry
- Filter: Pan-STARRS system g, r, i or z
g: $\lambda_{\text{ref}} = 485 \text{ nm}$, r: $\lambda_{\text{ref}} = 620 \text{ nm}$,
i: $\lambda_{\text{ref}} = 753 \text{ nm}$, z: $\lambda_{\text{ref}} = 867 \text{ nm}$



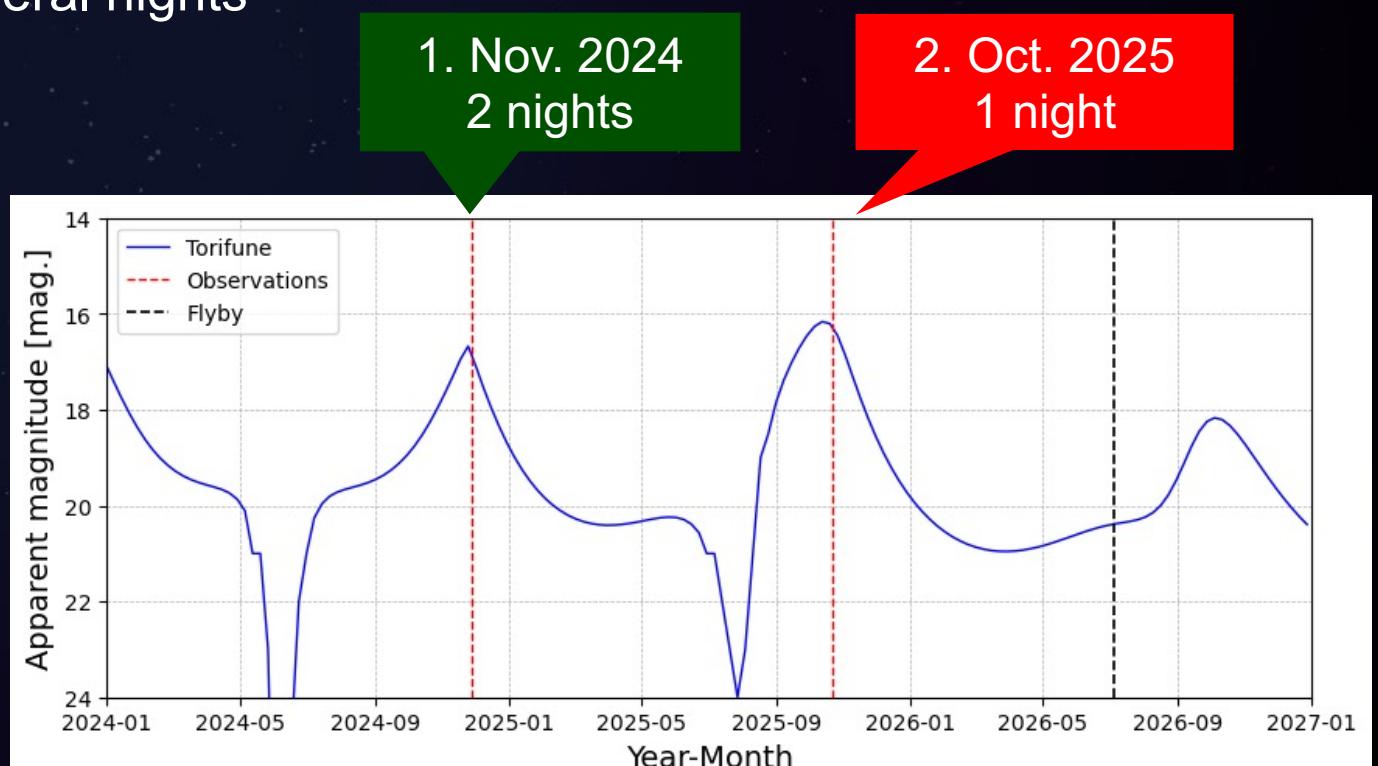
5. Observations

(Observation timing)

- Bright mag. timing
- Aimed for high photometric accuracy
- Proposal accepted and allocated several nights
- Before the Flyby

1. Observed at Nov. 2024
→Derived g, r, i color (but ~3 hours)

2. Will observe again at Oct. 2025
→Derive over 5 hours (Rot. period)
→High time resolution

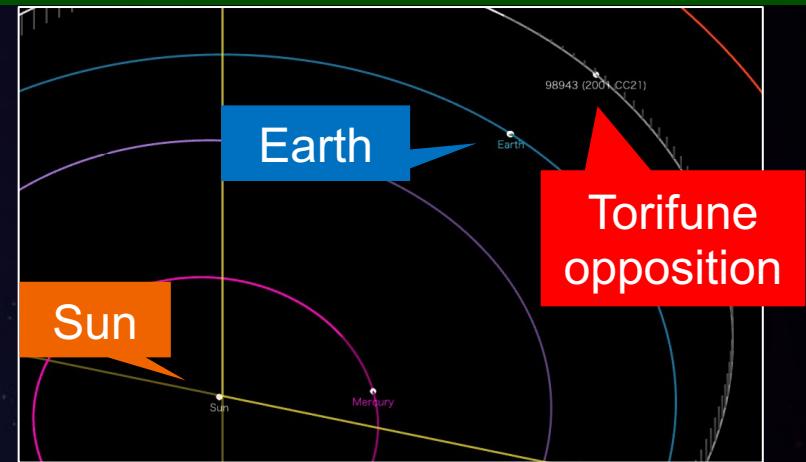


5. Observations

(Observation conditions)

- Allocated for 2 nights at 2024, 1 night at 2025

Position of Torifune at 28 Nov. 2024



2024	V-mag. [mag.]	α [deg.]	Exp. time [s]	Obs. time	Notes
27 Nov. 2024	16.7	5	12 s, S/N = 30-60 12 s \times 10 frames = 120 s, S/N = 100-150	~20 min.	Partly cloudy
28 Nov. 2024	16.8	6			

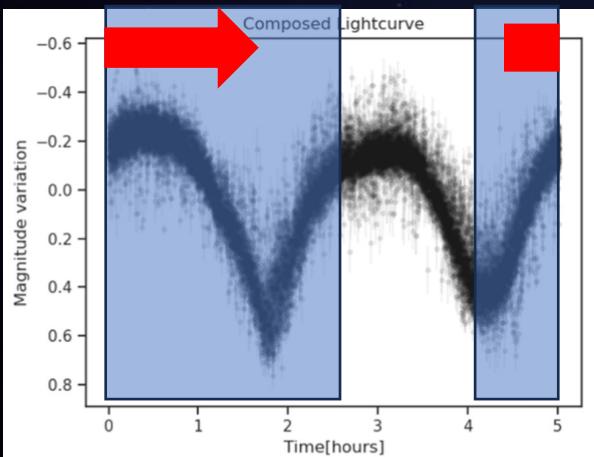
2025 Plan	V-mag. [mag.]	α [deg.]	Exp. time Plan [s]	Obs. time
22 Oct. 2025	16.2	20	4 s, S/N = 50-100 6 s, S/N = 60-120 (from Exp. time calculator)	Max ~5 hours

6. Results

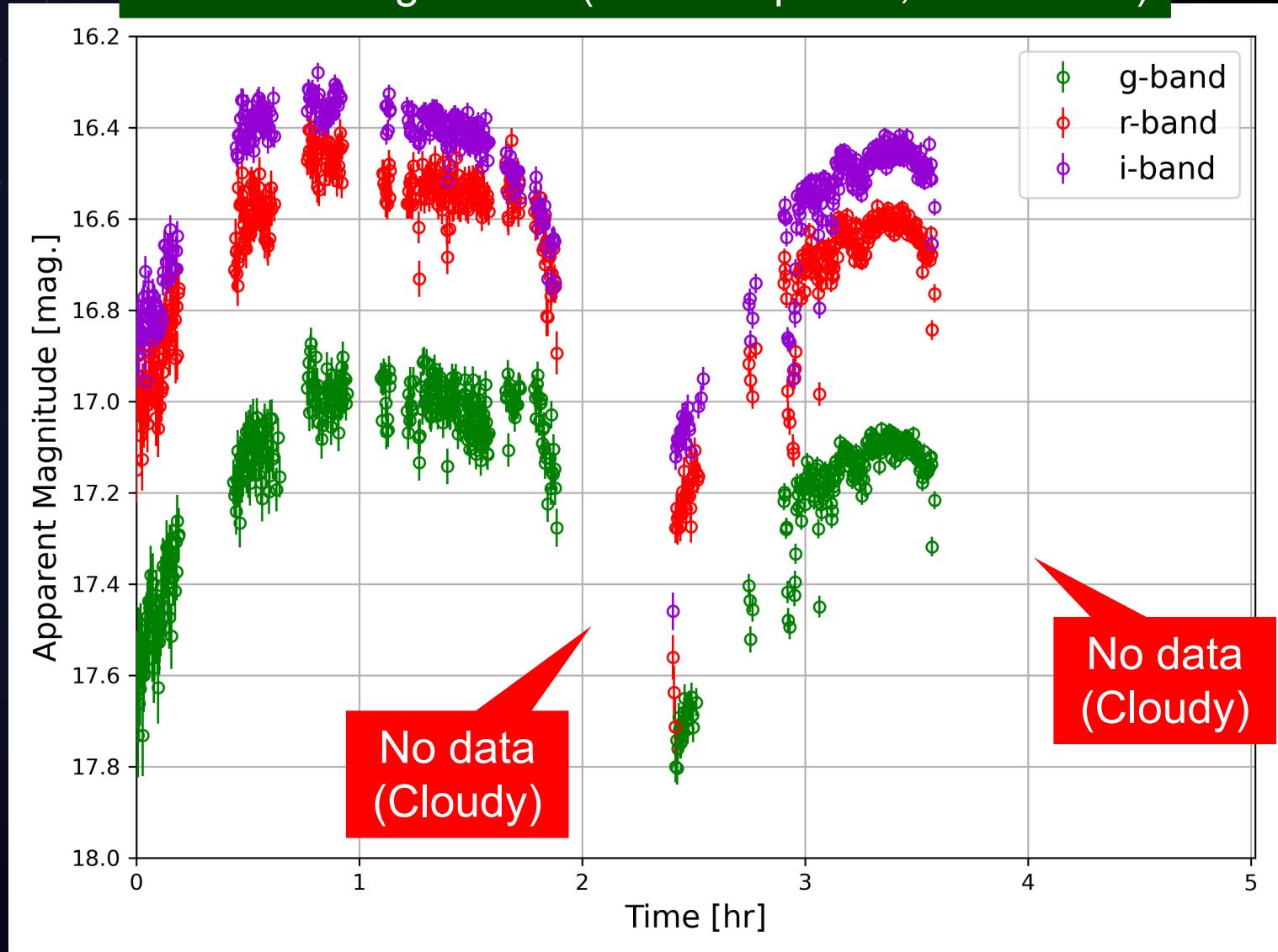
(Multi-color Lightcurve)

- Non-Stacked 12 s Exp. data
→ S/N = 30-60

- ~3 hours color data
→ Partly cloudy...



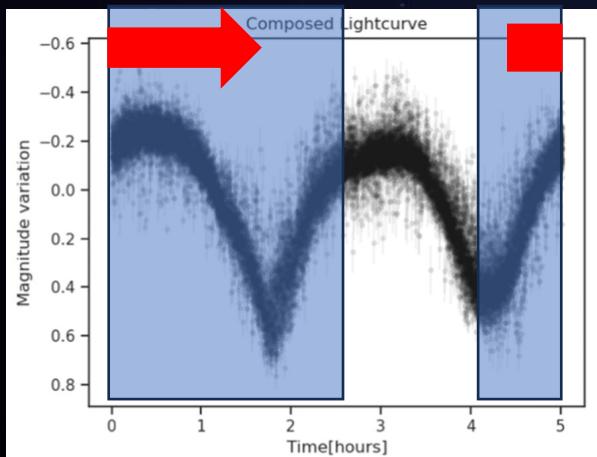
Multi-color Lightcurve (Rotation period; 5.02 hours)



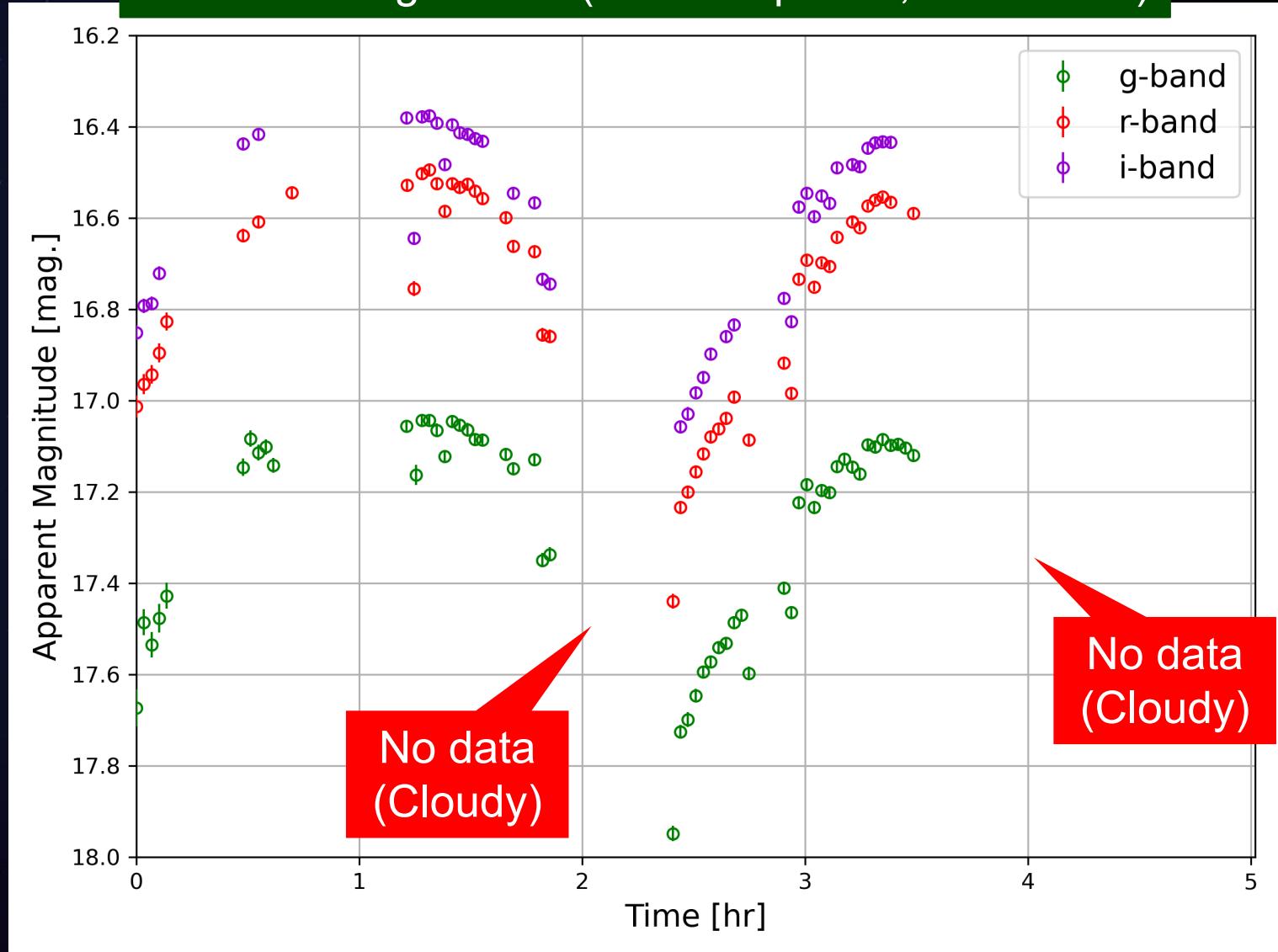
6. Results

【Multi-color Lightcurve】

- Stacked $12\text{ s} \times 10$ frames
→ Total 120 s (each points)
- S/N = 100-150
- ~3 hours color data
→ **Match for Lightcurve!**



Multi-color Lightcurve (Rotation period; 5.02 hours)

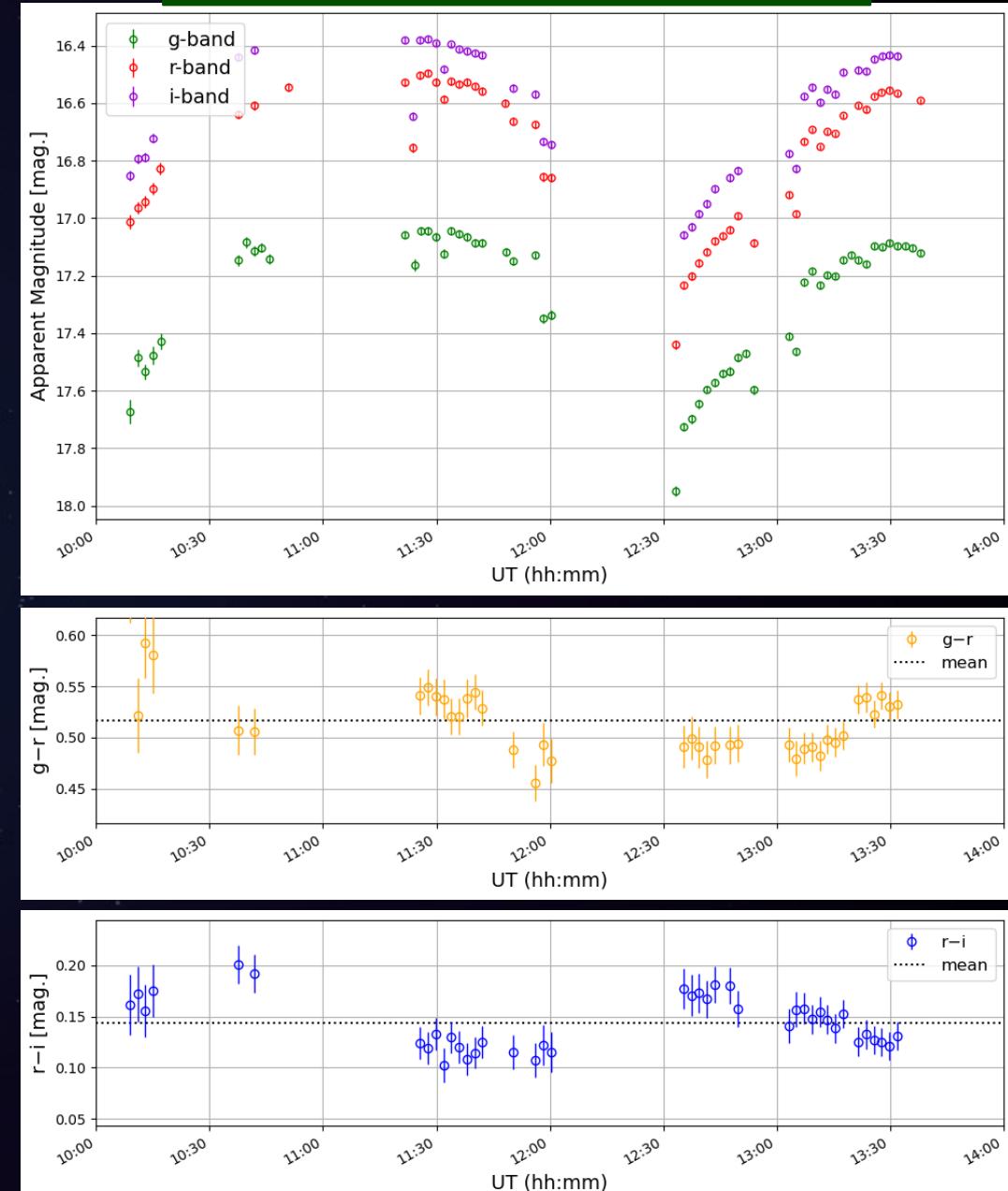


6. Results

(Color index variation)

- g-r & r-i variation is ~ 0.05 mag. from mean value
→ Consistent with **surface color homogeneity!**
- Smaller than that reported in a previous results
(Popescu et al., 2025)
→ Affected by the actual surface color and photometric accuracy
(sky condition and instrument)
→ Derived **high accuracy color data**
(Photometry S/N = 100-150)

Multi-color Lightcurve (UT)

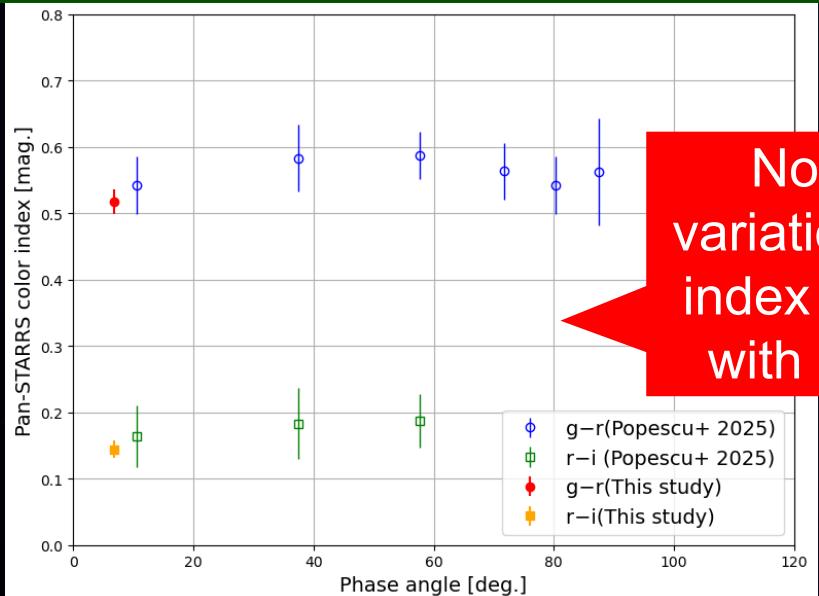


6. Results

[Mean color index]

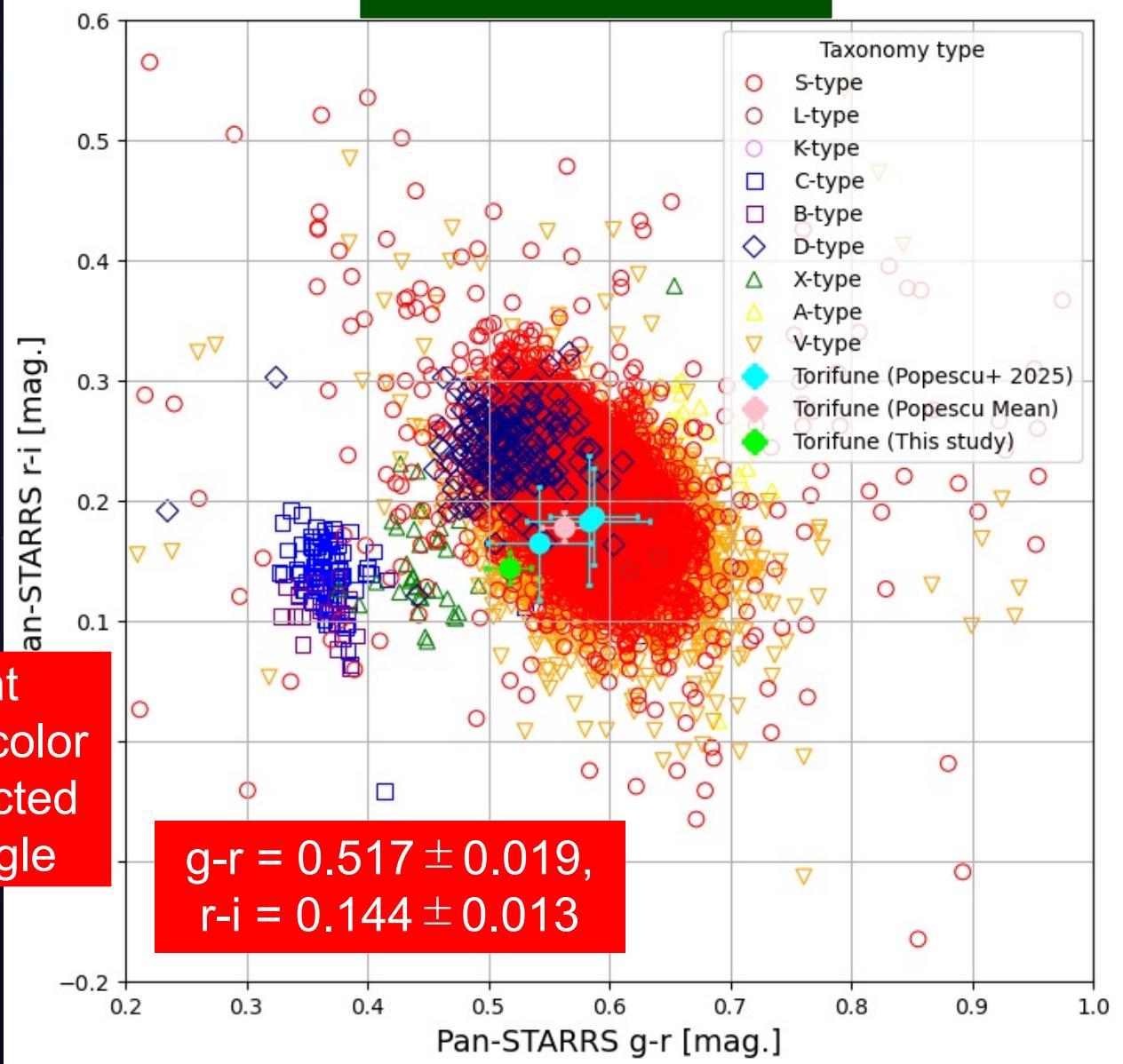
- $g-r = 0.517 \pm 0.019$, $r-i = 0.144 \pm 0.013$
(Pan-STARRS system)
→ **S-type (Good agreement!)**

Color index at each Phase angle



No significant variation in the color index was detected with Phase angle

Mean color index



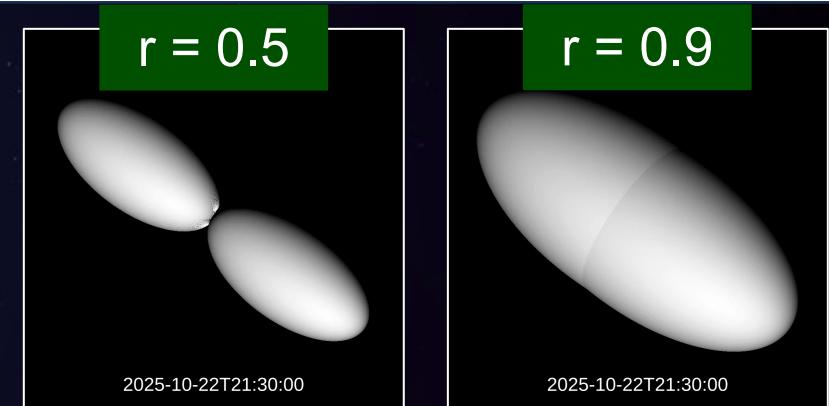
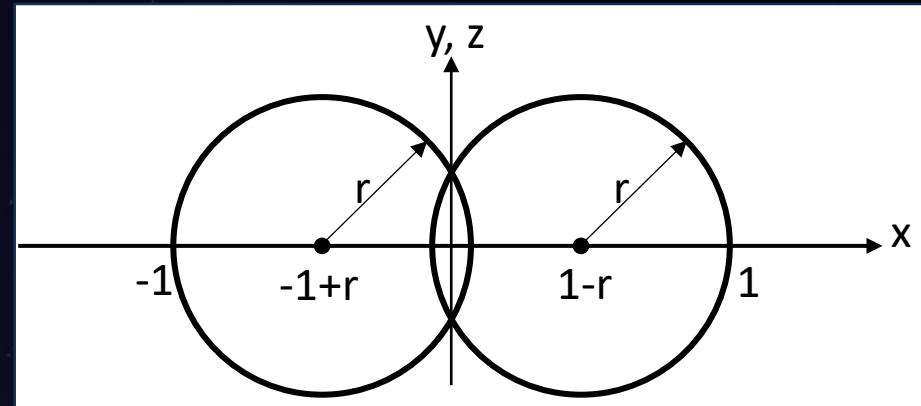
7. Next observing plan

(2024 Results)

- Confirmed high photometric accuracy at total Exp. time of 120 s
- Derived ~3 hours data (not enough)**



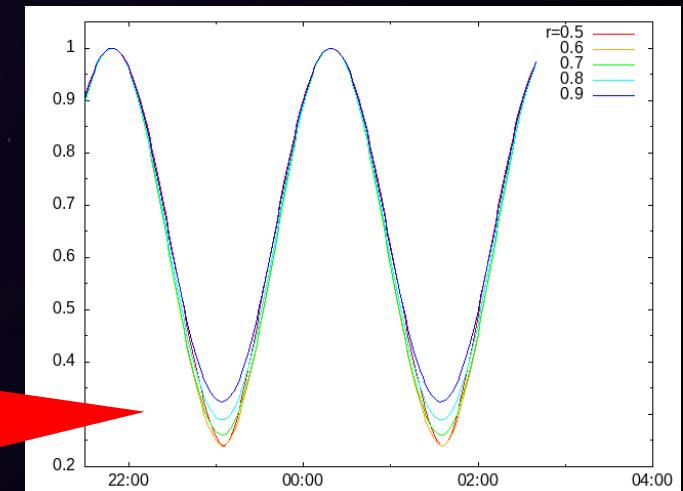
Made by
Sensyu-san!
@Chiba Tech.



(2025 Plan)

- Aim for high time resolution & derive over 5 hours data
- Exp. time 4-6 s for each frame (plan)
- Can detect features of contact-binary or not?

In the case of a contact-binary, the minimum brightness becomes deeper



8. Summary

(2024 Results)

- **S-type** color index
- Consistent with
surface homogeneity

(2025 Plan)

- Last chance before the Flyby
 - Over 5 hours data
 - High time resolution
- **22 Oct. 2025, 2-3Q**
(~21:30-26:30 JST)

This month! 2 weeks later!

Multi-color Lightcurve (Rotation period; 5.02 hours)

