2021 STELLAR OCCULTATION OBSERVATIONS OF ASTEROID (3200) PHAETHON FOR THE DESTINY+ FLYBY. T. Arai[1], F. Yoshida[2,1], T. Hayamizu[3,4], H. Akitaya[1], T. Okamoto[1], H. Noda[5], M. Ishiguro[6], S. Urakawa[7], T. Horaguchi[8], M.-Y. Yamamoto[9], G. Hashimoto[10], S. Matsuura[11], S. Marshall[12], and the DESTINY+ Occultation Observation Team. [1]Planetary Exploration Research Center, Chiba Institute of Technology, Chiba, Japan (tomoko.arai@it-chiba.ac.jp), [2] University of Occupational & Environmental Health, Fukuoka, Japan, [3]Saga Hoshizora Astronomical Center, Japan, [4]Japan Occultation Information Network (JOIN), Japan, [5]National Astronomical Observatory of Japan, Japan, [6]Seoul National University, South Korea, [7]Japan Spaceguard Association, Japan, [8]National Museum of Nature and Science, Tokyo, Japan, [9]Kochi University of Technology, Kochi, Japan, [10]Okayama University, Okayama, Japan, [11]Kwansei Gakuin University, Hyogo, Japan, [12]Arecibo Observatory & University of Central Florida, USA.

Introduction: DESTINY$^+$ (Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science) is a joint mission of technology demonstration and scientific observation, which will be launched in 2024 and flyby asteroid (3200) Phaethon in January, 2028 [1]. Phaethon is a parent body of the Geminids meteor shower [2, 3]. Asteroid 2005 UD is likely a break-up body from Phaethon [4]. Phaethon still actively ejects dust during every perihelion passage [5-9]. Phaethon passed 0.07 au from the Earth on December 16, 2017, which is the closest approach since 1974 and until 2093. During this apparition, global astronomical observation campaign of Phaethon was conducted [10], including optical, spectroscopic, polarimetric and radar observation with ground and space-based telescopes [11-23]. There were large differences in the size estimate between two-dimensional delay-Doppler radar images of Arecibo (6 km, dia.) [14] and thermophysical modelling results of observations from NEOWISE mission (4.6 km, dia.) [23]. The variable size estimates yield a range of albedo estimate of 0.09-0.16 [e.g. 15, 23]. To determine the size of Phaethon independently, observations of stellar occultation were conducted across the globe [24]. The best size information came from the July 29, 2019 event in the southwest U.S. [25]. The size and shape determination have been done based on the above occultation observation outcome combined with light curve and radar observation [26]. Yet, the shape model has 10-20% uncertainty [26] and thus further stellar occultation observation is needed to decrease the uncertainty. Here, we report observation results of stellar occultation by Phaethon in Japan and South Korea on October 13, 2021.

Occultation prediction: Predictions were made based on the new Gaia EDR3 catalog [27, 28]. The predicted occultation path in Japan on October 13, 2021 is shown in Fig. 1.

Observation equipments: Due to faint stars and short duration for occultation in most events, large telescopes of 20-30 cm coupled with GPS video-rate recording. QHY174M-GPS cameras with CMOS detector and integrated GPS receiver for accurate time tagging of images were used. The readout time was negligible.

Results: Total 35 stations with total 71 observers were deployed from the southwestern part of the main island of Japan to the southern part of South Korea. The weather was good at most of the observation sites. The observation was a huge success. Of the 35 observation sites, positive occultation was recorded at 17 sites and negative occultation at 7 sites. The reduction profile is shown in Fig. 2.

Size determination: The size of Phaethon derived from the October 13 observation is 6.13±0.05 km, 4.40±0.06 km. The shape indicated by the result is more flattened in both polar regions than previously estimated (Fig. 3). The 3D shape model of Phaethon is currently being updated with the observation result.

References: [1] Arai T. et al. (2021) *52nd LPSC*, Abstract #1896. [2] Whipple F.L. (1983) IAU Circ., 3881. [3] Williams I. P. and Wu Z. (1993) Mon. Not. R. Astron. Soc. 262, 231-248. [4] Ohtsuka K. et al. (2006) A&A 450, L25. [5] Jewitt D. and Li J. (2010) AJ. 140, 1519. [6] Jewitt D.et al. (2013) ApJL, 771, L36. [7] Hui M.-T. & Li J. (2017) AJ 153, 23. [8] Jewitt D. et al. (2018) AJ 156, 238. [9] Ye Q. et al. (2018) ApJL 864, L9. [10] Arai et al. (2019) LPSC 50th, abstract#3223. [11] Kim M. -J. et al. (2018) A&A 619, A123. [12] Hanuš J. et al. (2018) A&A 620, L8. [13] Takir D. et al. (2018) LPSC 49th, abstract#2624. [14] Taylor P. A. et al. (2019) PSS 167,1. [15] Kareta T. et al. (2018) AJ 156, 287. [16] Ito T. et al. (2018) Nature Comm. 9, 2486. [17] Shinnnaka Y. et al. (2018) ApJL 864, L33. [18] Borisov G. et al. (2018) MNRAS 480, L131-135. [19] Devogèle M. et al. (2018) MNRAS 479, 3498. [20] Zheltobryukhov M. et al. (2018) A&A, A179. [21] Lee H.-J. et al. (2018) PSS 165, 296. [22] Lazzarin M. et al. (2019) PSS 165, 115 [23] Masiero J. R. et al. (2019) AJ 158, 7. [24] Arai T. et al. (2020) *51nd LPSC*, Abstract #2924. [25] Marshal S. (2020) IDP symposium 2020. [26] Dunham et al. (2019) abstract for Asteroid Science in the Age of Hayabusa2 and OSIRIS-REx. [27] Gaia Collaboration et al. (2016) A&A 595, A1. [28] Gaia Collaboration et al. (2018) Gaia Data Release 2. Summary of the contents and survey properties.

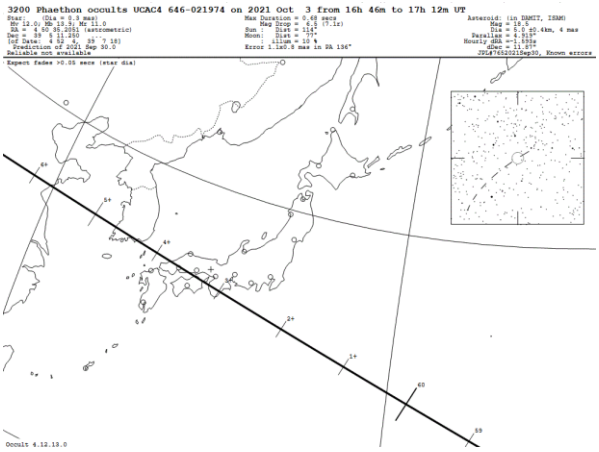

Fig 1. Predicted occultation paths on Oct. 13, 2021. (generated by T. Hayamizu from OCCULT4.12.13.0)

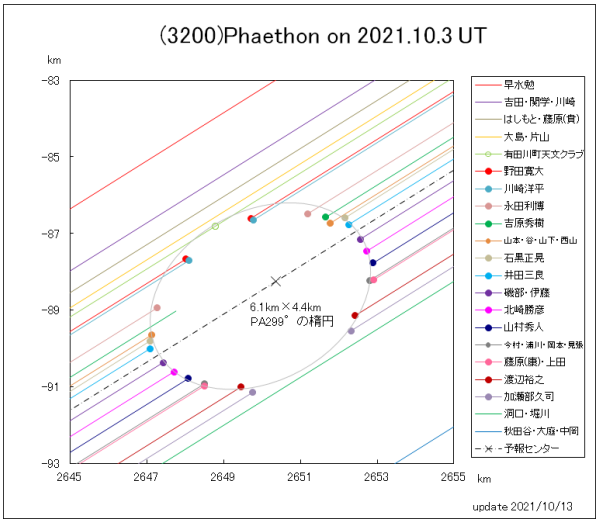

Fig. 2 The reduction profile of Oct. 13 observation. (generated by T. Hayamizu)

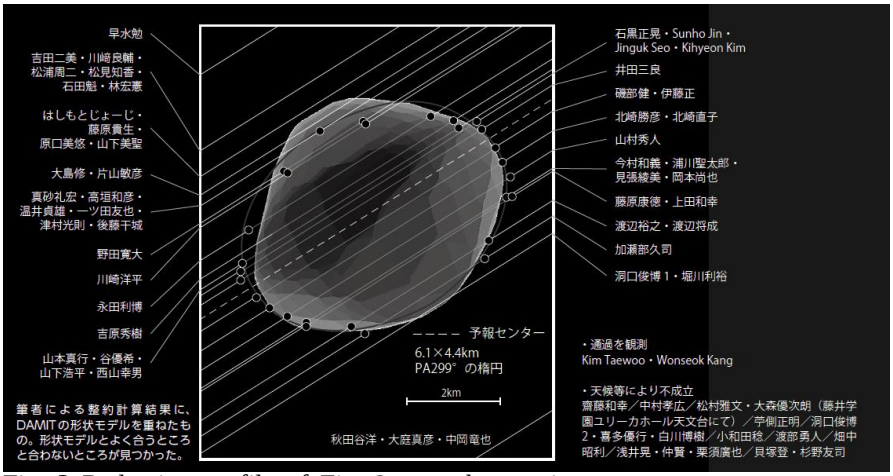

Fig. 3 Reduction profile of Fig. 2 onto the previous shape model. (generated by T. Hayamizu)