Subaru High-Contrast Imaging Are Critical for Technical Demonstration and Scientific Studies of the Roman Coronagraph

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Subaru Instrument: SCExAO/CHARIS, REACH, VAMPIRES (possibly, exo-NINJA)

Number of nights (hours): 30 nights

Condition of nights (moon phase, airmass, seeing): no restriction for moon phase, airmass < 2.0, seeing < 1.0”

Time critical (year, season, date, time): in 2027 (= Phase 1: 25 nights) + in 2028–29 (5 nights = Phase 2)

Relevant CCS/other Roman program: Coronagraph Instrument (high contrast imaging)

Category(exoplanet, galaxies, large scale structure, solar system, stellar physics, stellar population/ISM, super massive blackhole/AGN, IGM/CGM): exoplanet

Key words: high contrast direct imaging, planet, brown dwarf, atmosphere, spectroscopy

Goals and Targets of Roman High Contrast Imaging

- **Roman-Coronagraph: technical demonstration for a future mission that is for imaging an Earth twin (i.e., HWO), but available for sciences after the first observation phase.**
- First demonstration goal: achieve a contrast of 10^{-7} - 10^{-8} at 580 nm over a dark-hole area (= 6–9 λ/D) with a total integration of few hours for a very bright star (V < 5–6)
  - It is essential to test the performance by detecting an actual companion with a contrast of 10^{-7} - 10^{-8}, rather than an evaluation based on noise level.
  - **The detection of a companion having the above contrast level enables scientific studies simultaneously as the demonstration.**
  - The **samples must be located within 5° in Ecliptic longitude** from bright reference stars (V < 3; diameter < 2 mas), which are observed for modeling a dark hole but **sparse over the sky**
  - **Few known samples** meet the above requirements.
  - The Subaru team is now conducting a survey to find substellar companions around bright stars, potentially providing the samples suitable for the Roman (below, **this survey = the ongoing survey**)

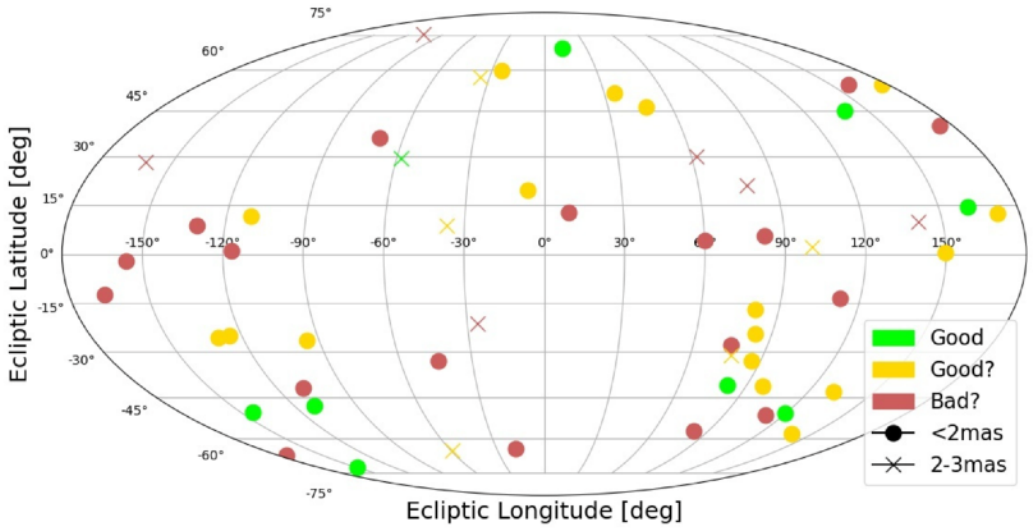
Subaru SCExAO Survey for Roman Targets: Phase 1

- Only our ongoing survey (see 2nd page) may not be able to find enough samples, due to the restrictions from e.g.
  - the visibility of targets observable in time-window allocated to the Roman coronagraph project
  - Small separation angles between references and science targets

We propose a Roman-Subaru synergetic program to increase the samples

- 25 nights are requested to discover 5 substellar companions that are suitable for the Roman corongraph

Map of selected dark-hole references (credit: J. Hom)



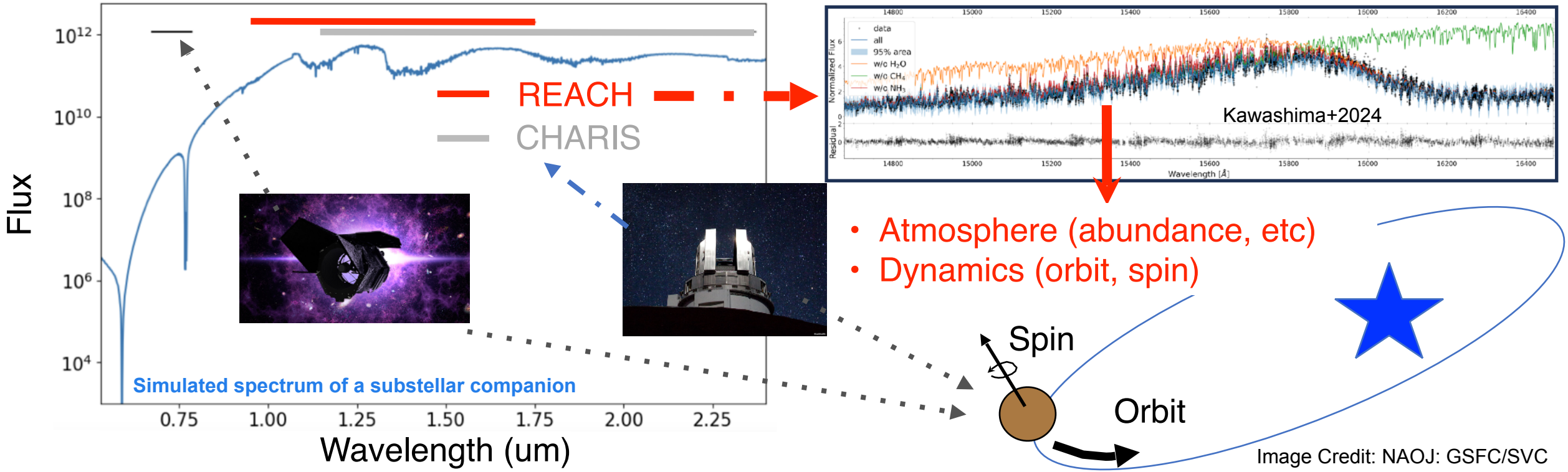
We are vetting candidates of reference star now

- Adopt the target-selection policy optimized for the Roman coronagraph: all the targets (N~60) will be selected from the young stars that are appropriately close (< 5°) to reference stars
- We expect leveraging Gaia DR4 data boost discovery prospects by several-fold

Follow-Up Characterizations: Phase 2

- Request additional 5 nights for in-depth characterization of ~5 best samples from our surveys, which we also propose to observe with Roman (note 1st phase + Roman already enables some characterizations)
- Reveal atmosphere, orbit, and obliquity of substellar companion by comprehensively analyzing all the imaging and spectroscopy data

Spectroscopic and imaging characterization with Subaru and Roman



Summary

- The targets for the Roman coronagraph should be very close ($\Delta < 5°$ in Ecliptic longitude) to dark-hole reference stars, which are sparse over the sky
- It is important to create the sufficient list of substellar companions suitable for demonstrating the Roman's high-contrast performance, to avoid a risk that there will be no targets available in the time allocated for the coronagraph project of Roman
- Discover ~5 substellar companions using Subaru and image them at visual wavelengths using Roman, fulfilling one of the Roman's missions and enabling the first visible-to-infrared characterization of a substellar-mass companion (e.g., constraint on cloud, composition)
- Characterize companions discovered by Subaru and followed up by Roman, using the unique capability of the Subaru Telescope for high-contrast spectroscopy

Significance of Synergy: Subaru observations are crucial not only for achieving a key goal of Roman's coronagraph project but also for advancing scientific studies via Roman's high-contrast imaging and for fully characterizing substellar companions observed by Roman.