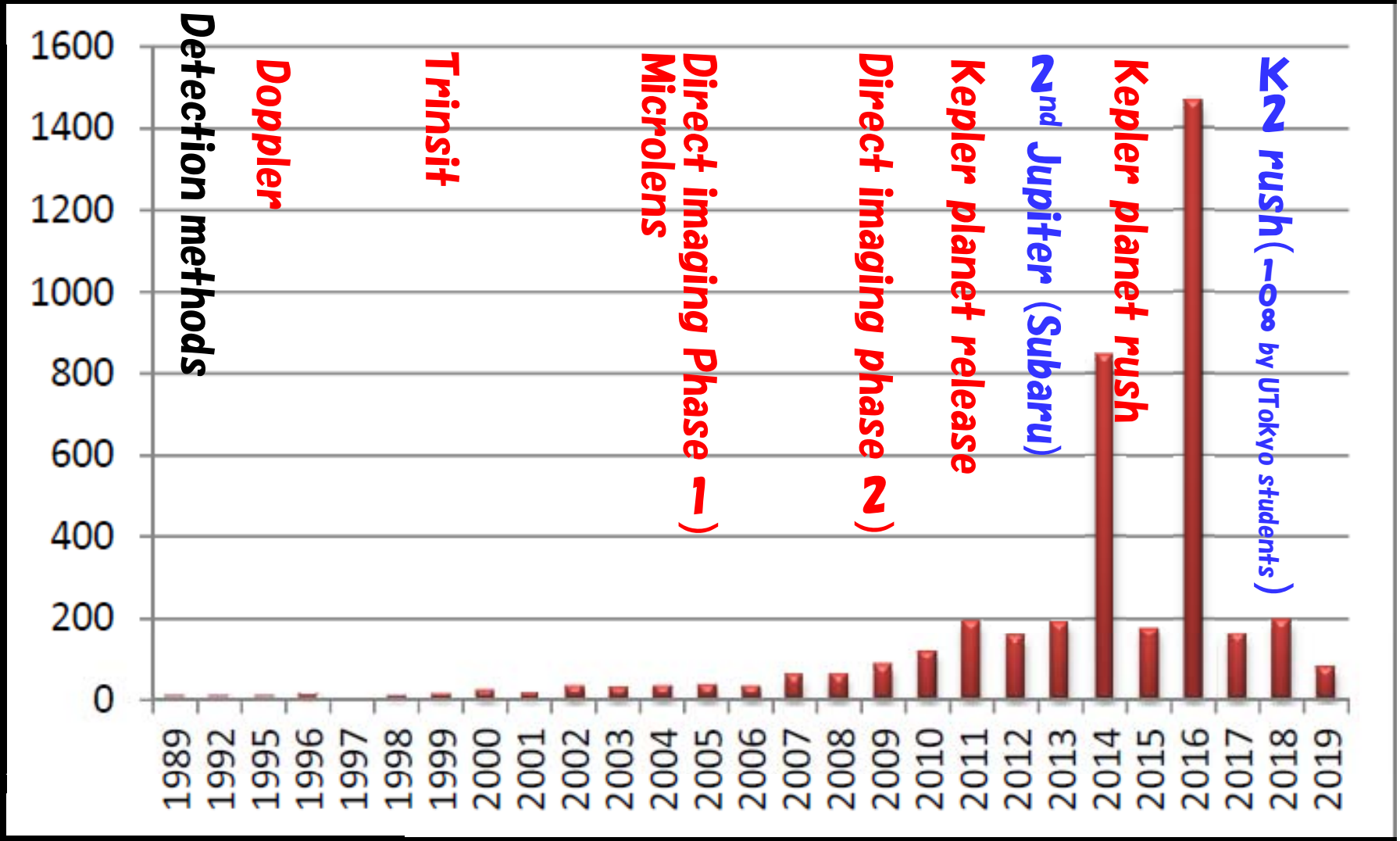
TMT時代の系外惑星観測と観測装置

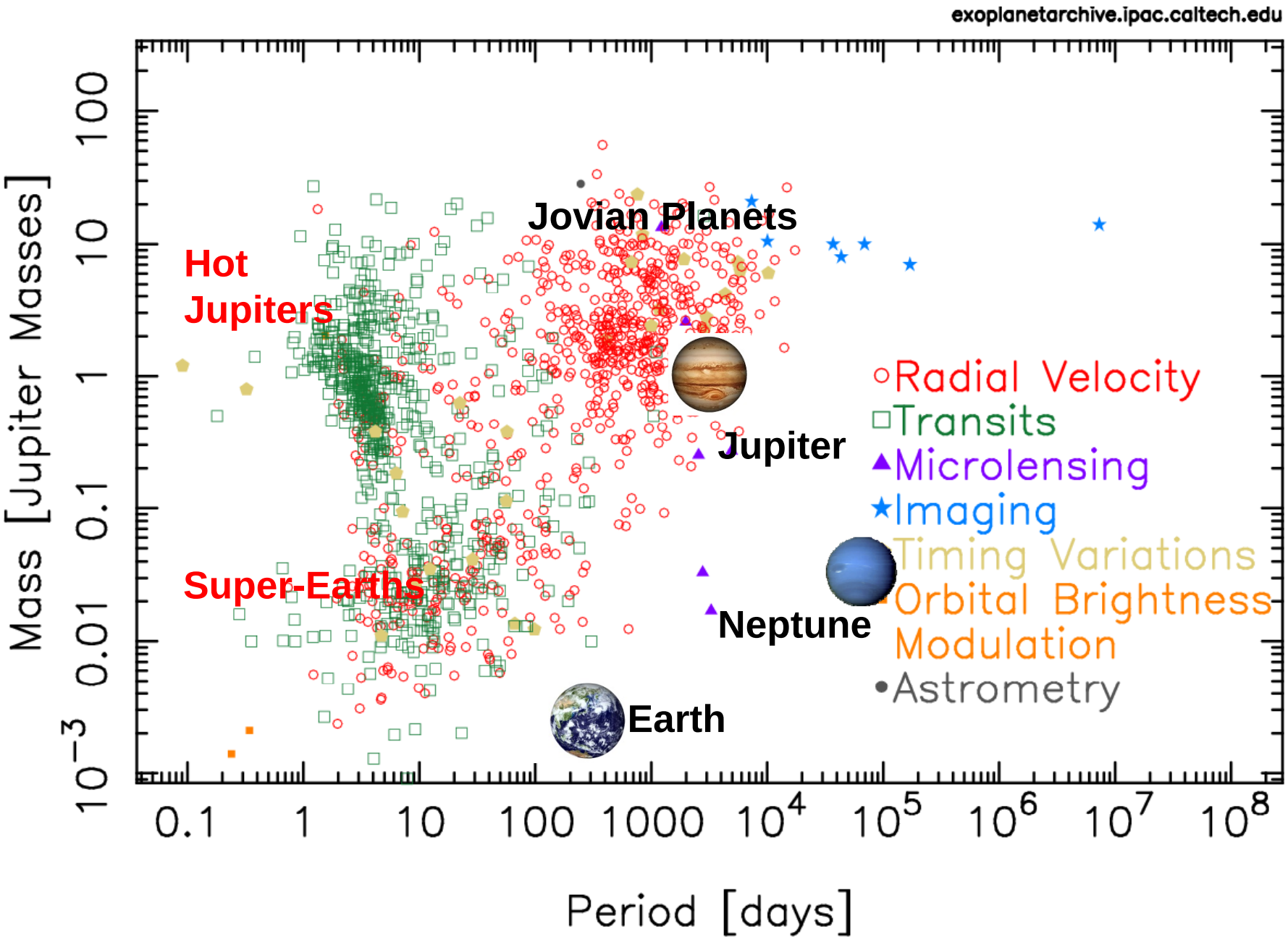
2019.9.13 13:48-14:00
E 会場

UTokyo, Dept. of Astronomy
Astrobiology Center of NINS
NAOJ of NINS
Motohide Tamura

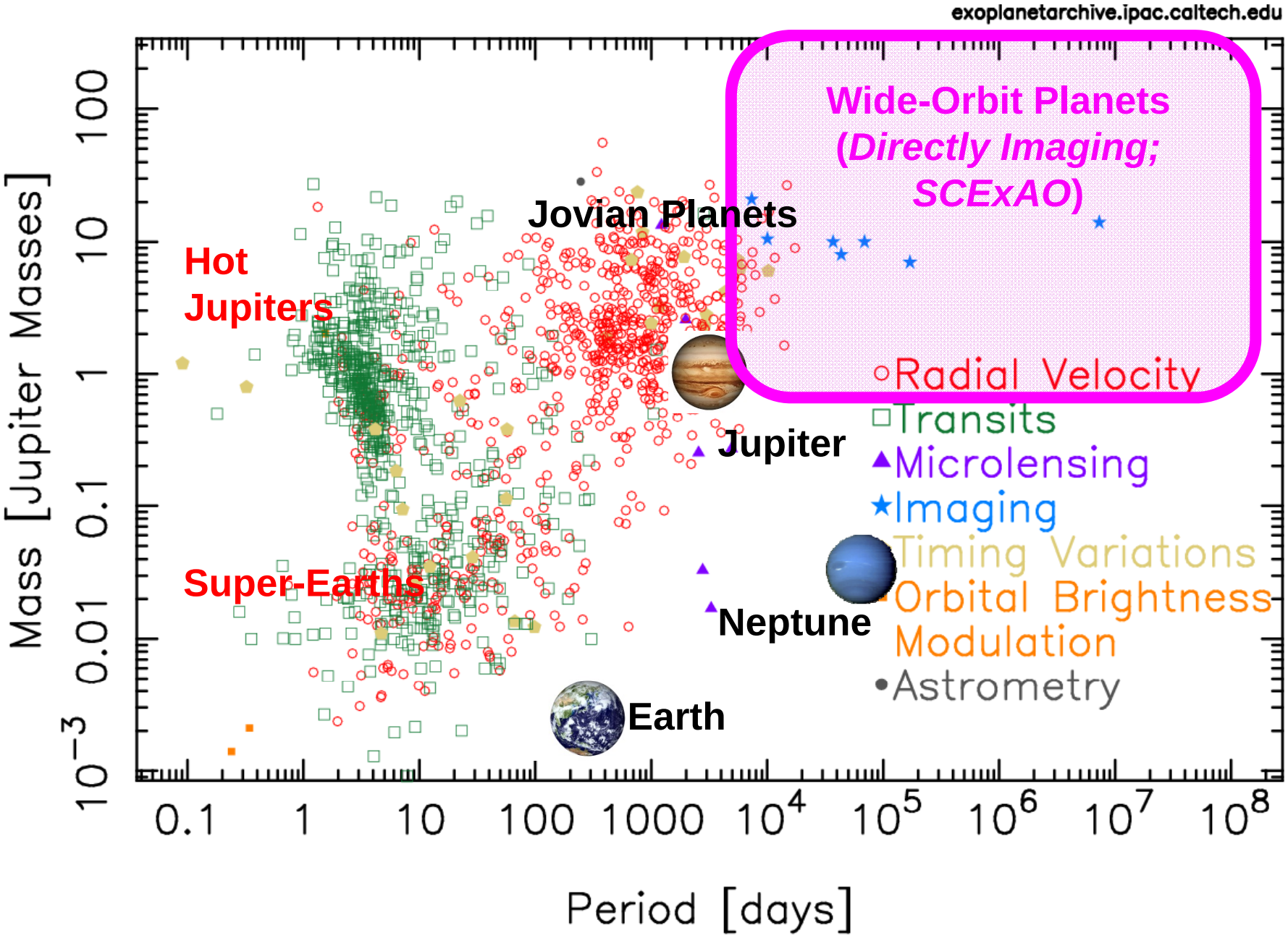
Various techniques have discovered >4000 planets (confirmed) with various methods



Various Planets detected by Various Techniques



Direct Imaging can now image wide-orbit planets



Directly Imaged Planets Gallery

(not full list & SEEDS planets introduced in detail later)

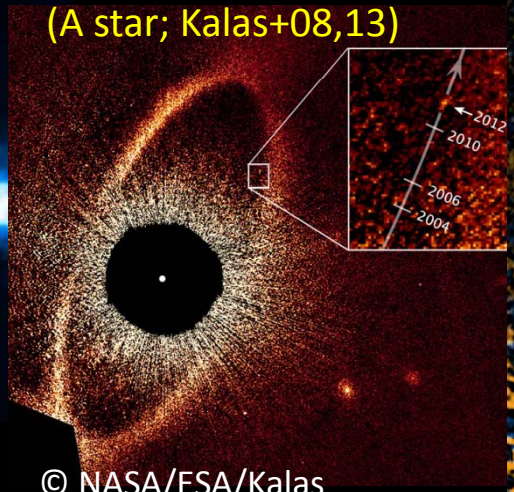
HR 8799 bcde
(A star ;Marois+08,10)

©NRC-HIA, Marois
& Keck Observatory

β Pic b
(A star; Lagrange+10)

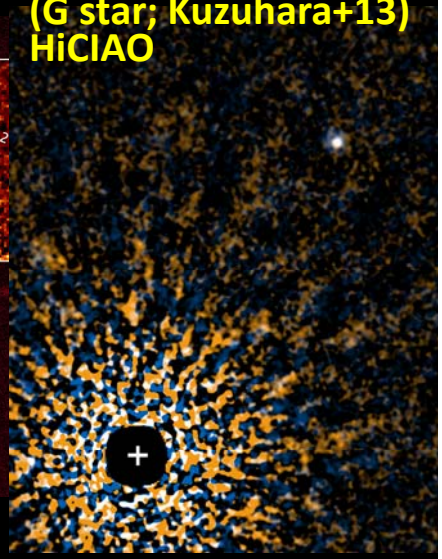
©ESO/Lagrange

Fomalhaut b ??
(A star; Kalas+08,13)



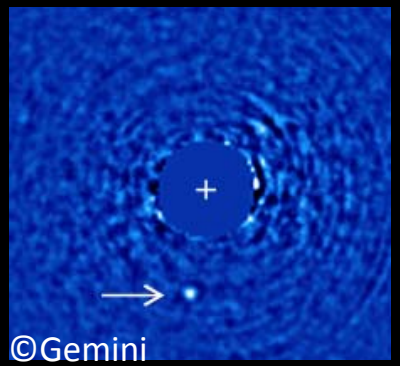
© NASA/ESA/Kalas

GJ504 b
(G star; Kuzuhara+13)
HiCIAO



©NAOJ/Subaru/ABC

51 Eir b
(F star; Macintosh+15)

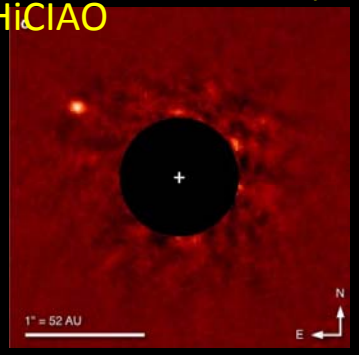


©Gemini

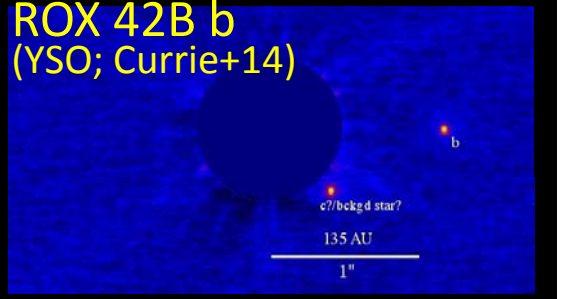
2M1207 b
(BD; Chauvin+04,05)

©ESO/VLT

Kappa And b
(B star; Carson+12)
HiCIAO



ROX 42B b
(YSO; Currie+14)

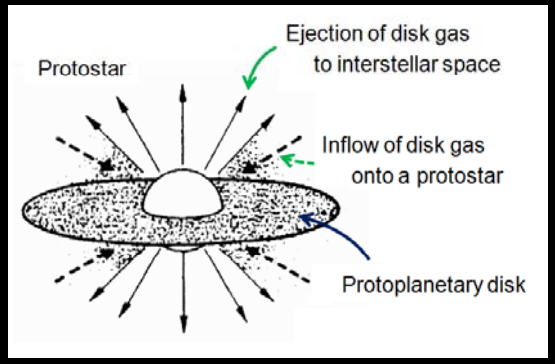


©NAOJ/Subaru

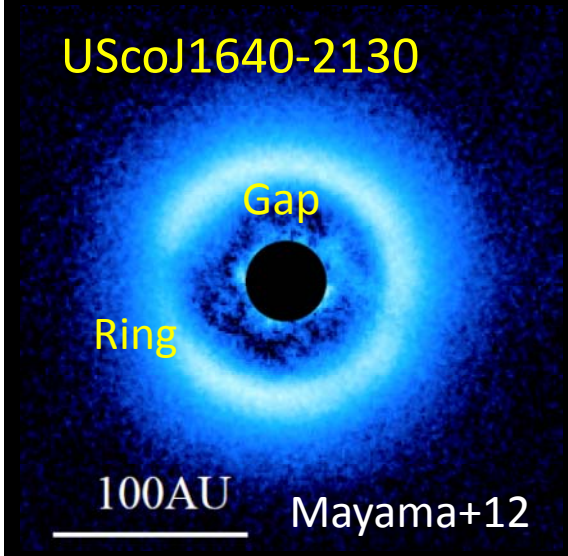
Wide-orbit planets can be detected currently only by direct imaging;
Many are a>=100 AU; ***only handful for Solar-system-scale orbit planets.***

Major Results of Planet Formation Sites

SEEDS has observed **scattered light** from disks and revealed many disk structures **of less than 100AU scale** that are **possible signs of planet formation in such young (a few Myr) systems!** **Many directly-maged small gaps/spirals in disks since 2010.**



Hubble Telescope image is not enough to study disk structure…

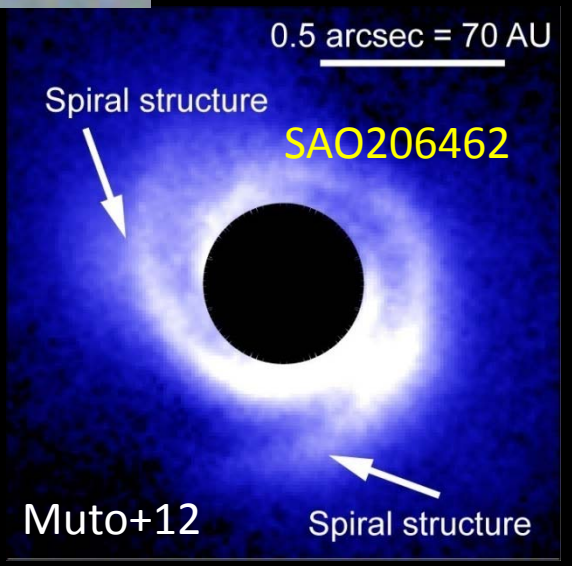


☐ **Gaps**

A disk gap may be evidence for dynamical interactions between a planet and its gaseous disk.

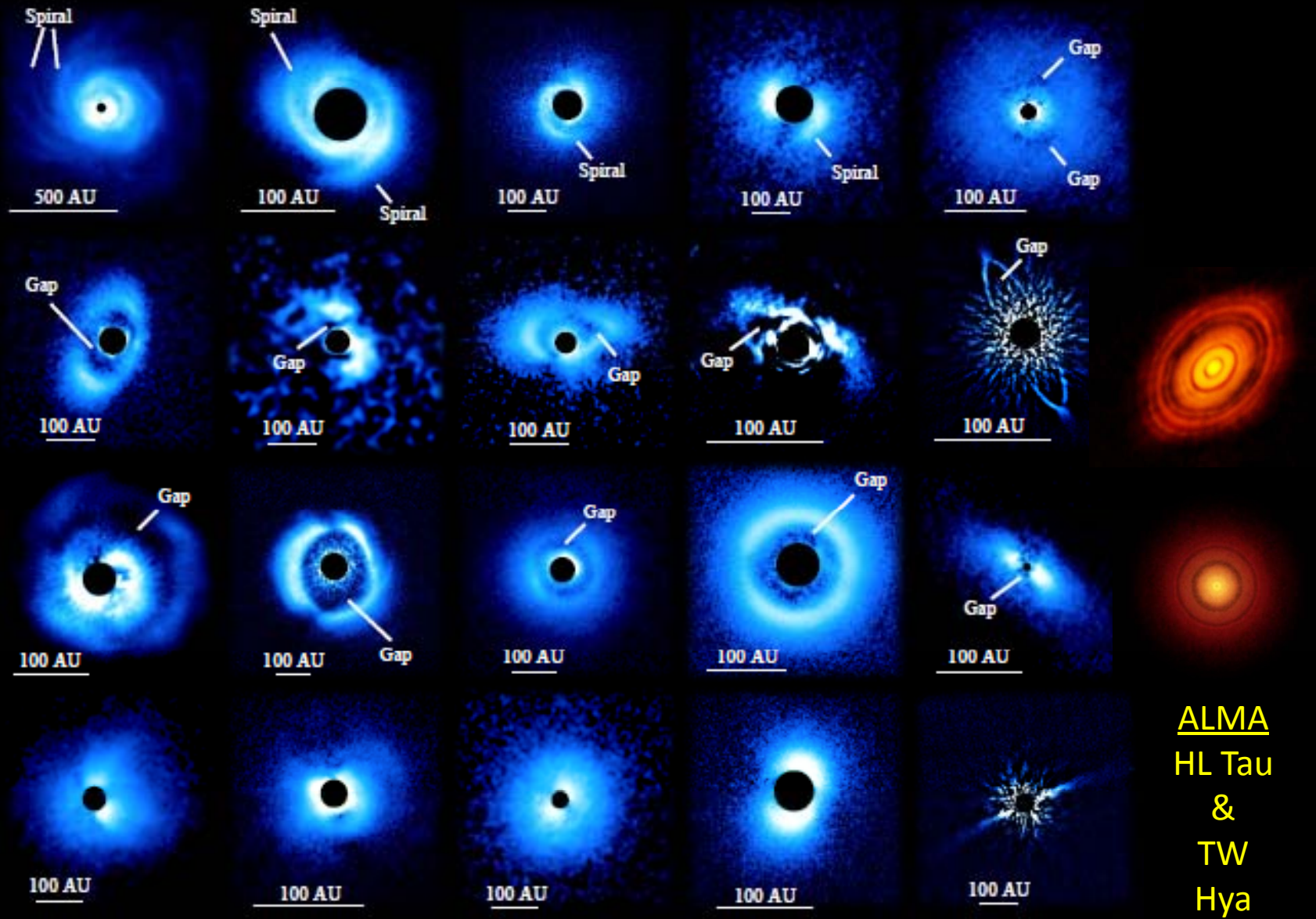
☐ **Spirals**

A gravitational perturbation from an embedded planet generate spiral density waves.



SEEDS has revealed gaps & rings of <100AU scale in many disks by polarimetric imaging (Res.~0.06", IWA~0.1") since 2010

Note that ALMA HL Tau image (2015) is thermal emission .

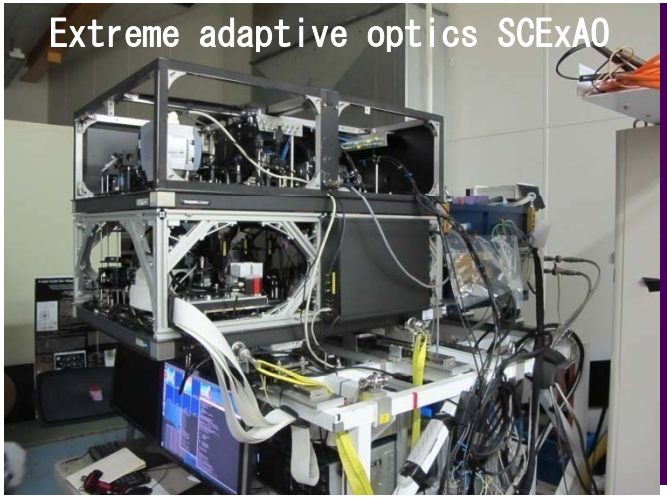


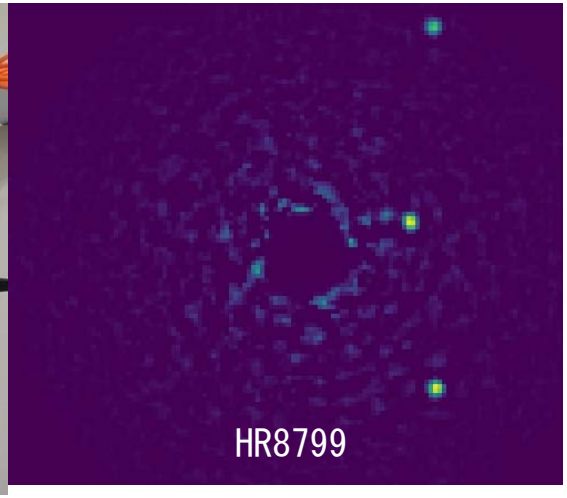
ALMA
HL Tau
&
TW
Hya

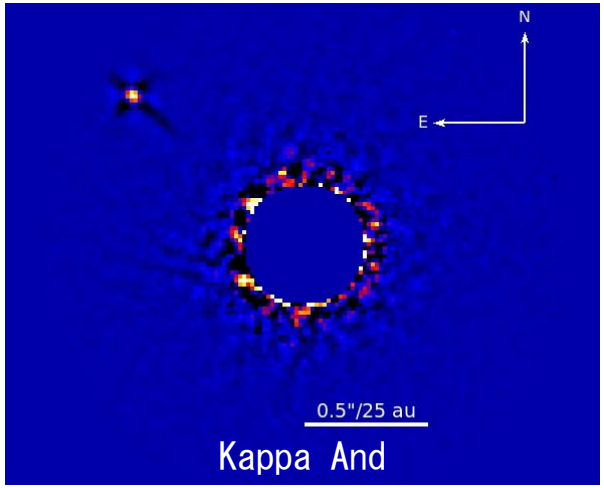
Direct Imaging instruments SCExAO/CHARIS

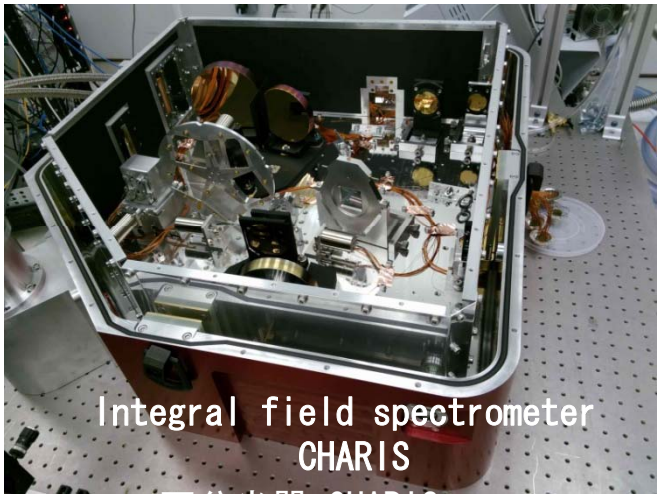
Enabling direct spectroscopy on Subaru

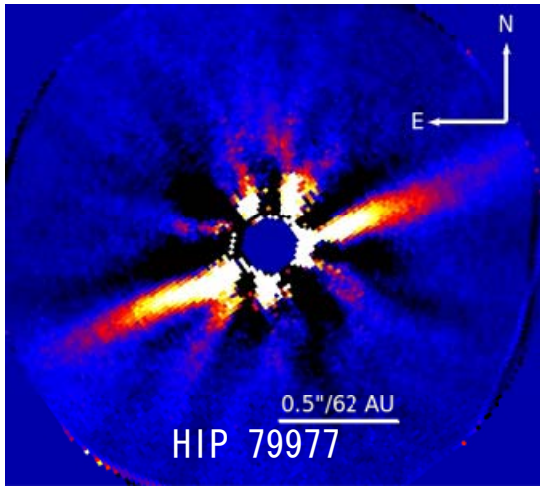
Open use on Subaru, Publication rush now.

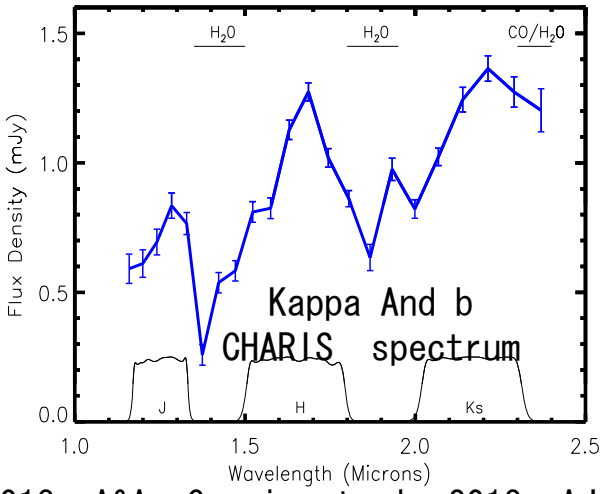






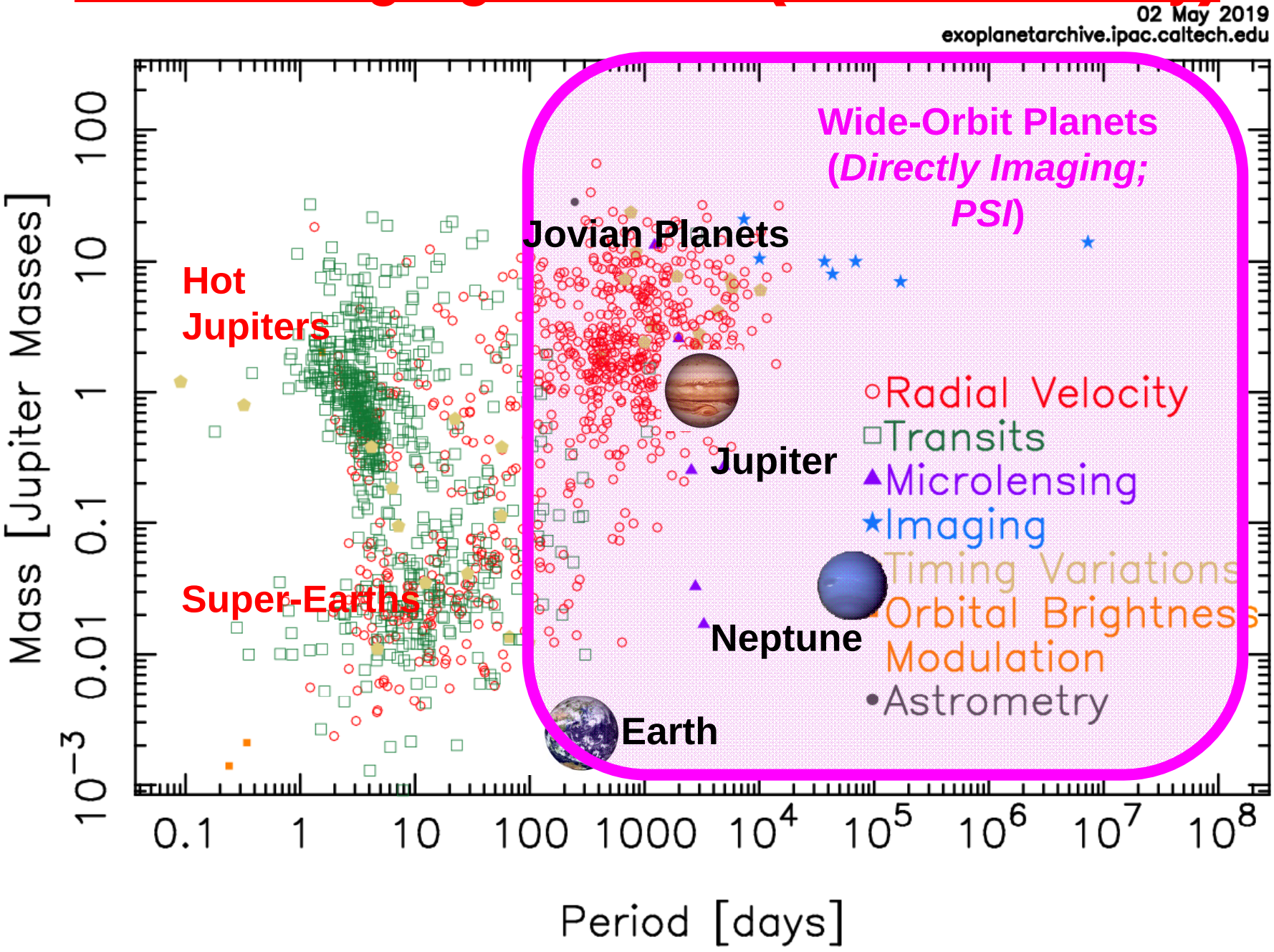






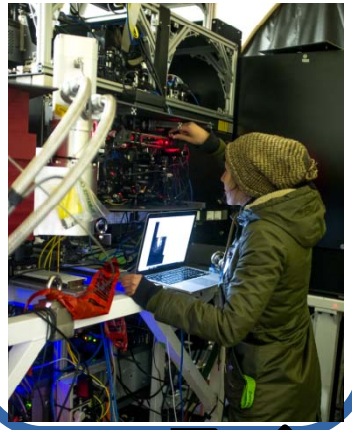
Uyama et al. 2019; Currie et al. 2019, ApJ; Asensio-Torres et al. 2018, A&A; Currie et al. 2018, AJ; Goebel et al. 2018, AJ; Guyon 2018, ARAA; Rich et al. 2018, AJ.

Direct Imaging with TMT (but not excatly)



Our Strategy to "2nd Earth" Imaging

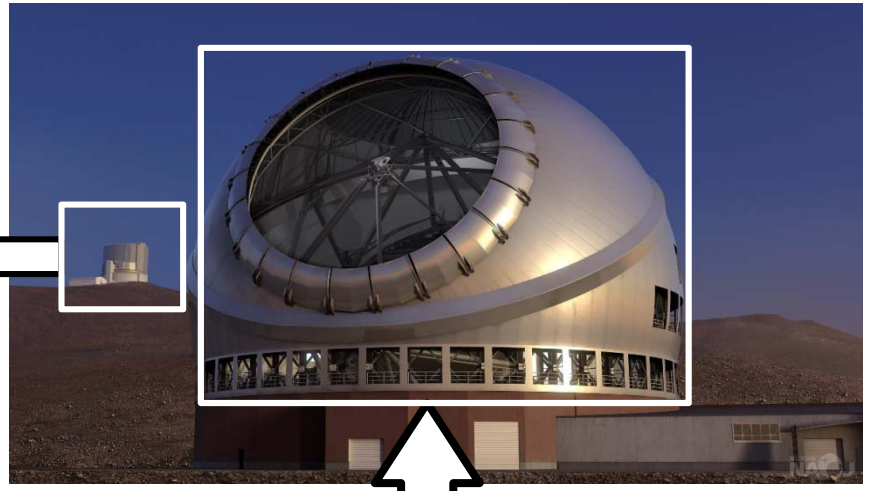
Develop and Validate Critical Technologies



Enable

Validate

Observe Giant Planets in reflected light @ Subaru Telescope

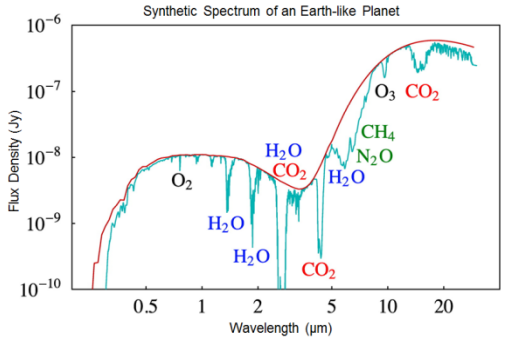


Measured on-sky performance

Technology requirements

Experience in on-sky operation and scientific analysis

Coordinate with TMT International Observatory



Science measurements, Exoplanet targets

Instrument design, deployment plan

Formulate Detailed Plan for Probing for Extrasolar Life with TMT

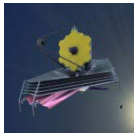
From Guyon

SCExAO/TMT vs. Future Missions

☐ **Current Ground-based Surveys:**

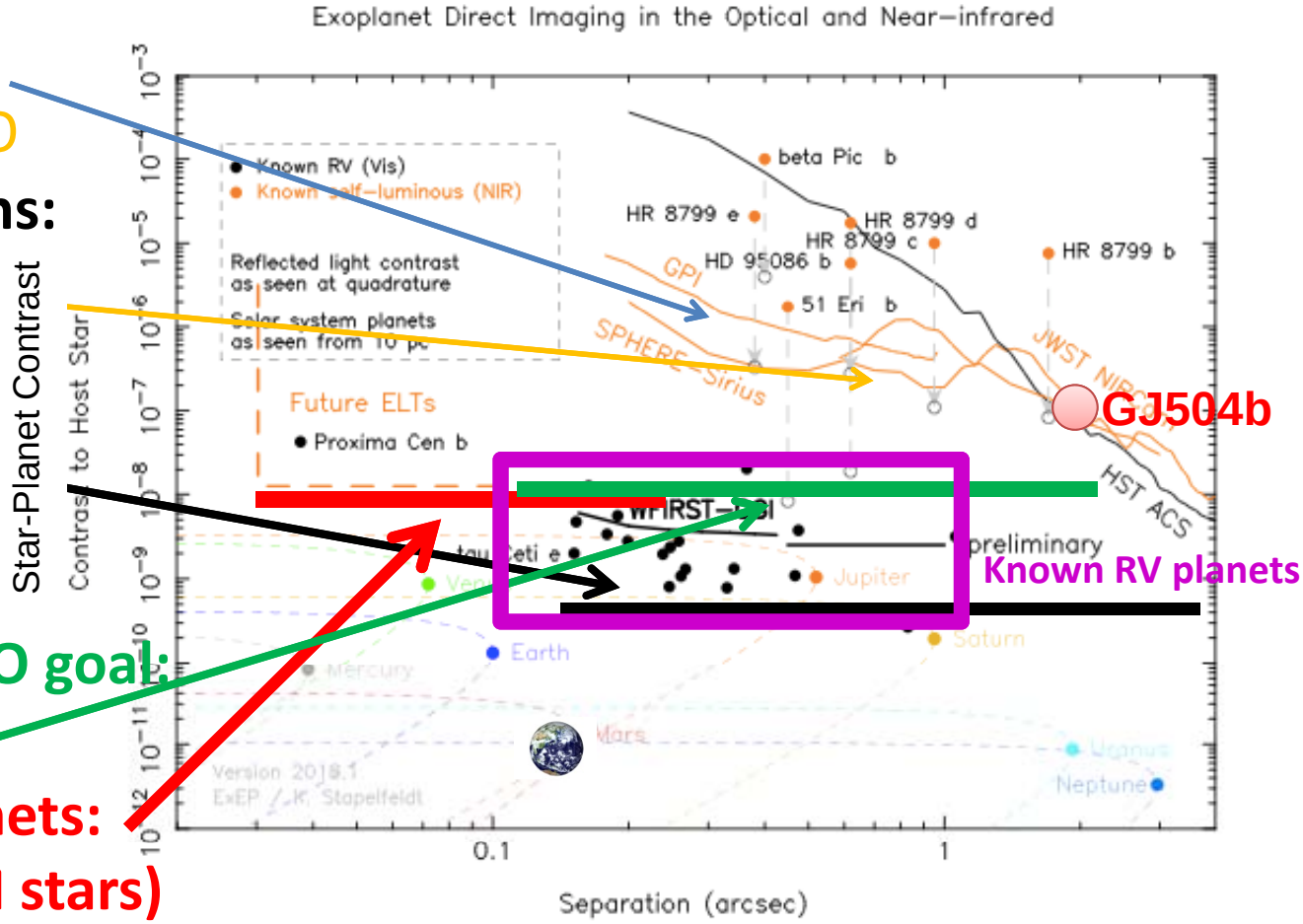
- GPI survey
- SPHERE survey
- Current SCExAO

☐ **Future missions:**



JWST coronagraph

WFIRST coronagraph



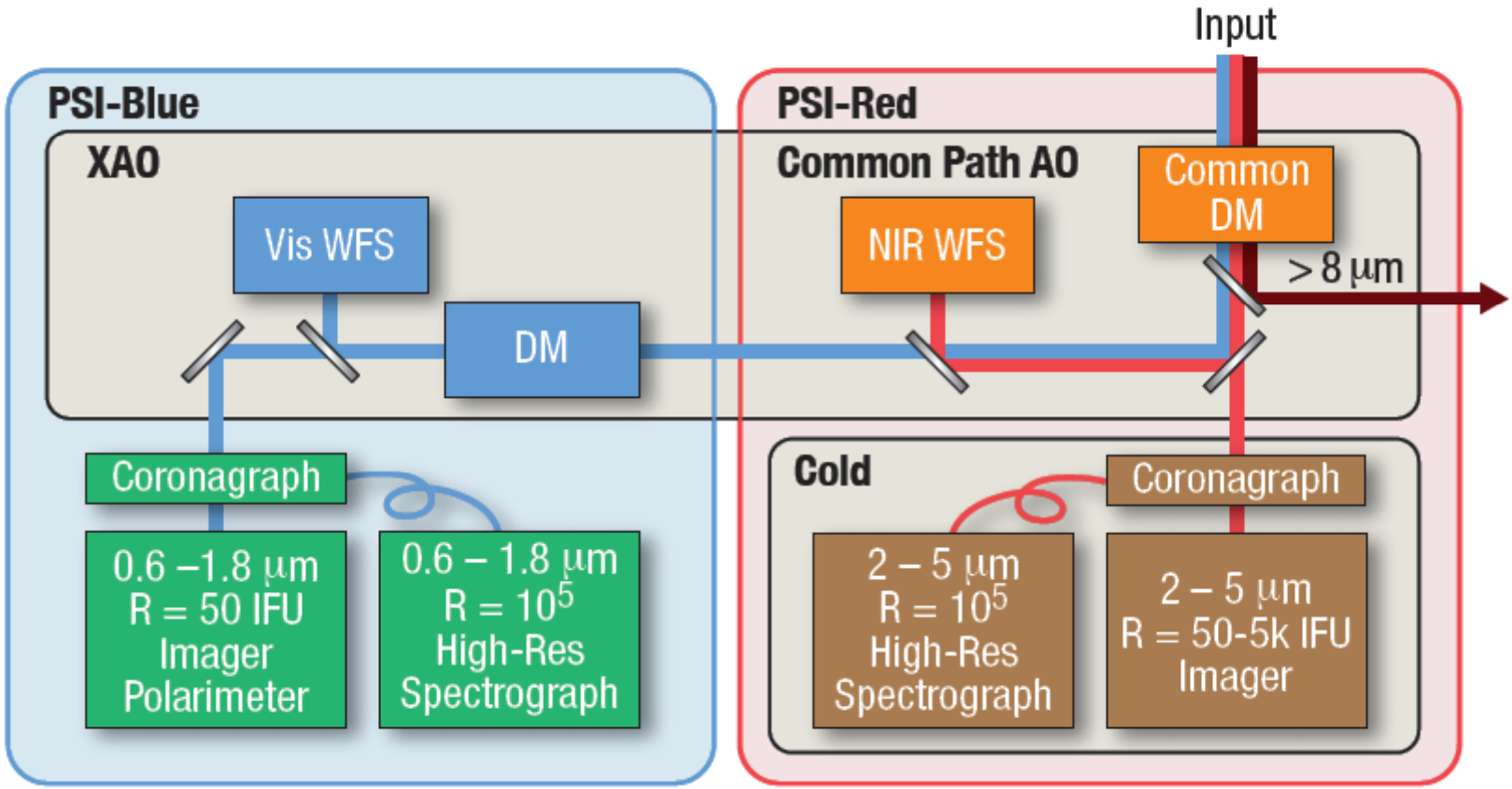
☐ **Subaru SCExAO goal:**

- **10^-8 at 0.1”**

☐ **Earth-like planets:**

- **TMT+PSI/b (M stars)**
- **10^-8 at 0.01”**

PSI: a modular 2nd Earth Imager



PSI/blue spec

Wavelength: 0.6-1.8 um
Contrast: 10^(-8) at 1-2λ/D
Own DM (tweeter): maybe MEMS
- 100 x 100 actuators minimum
- Stroke: > 1 um
- Speed: 5 kHz, - Actuator pitch: < 0.5mm

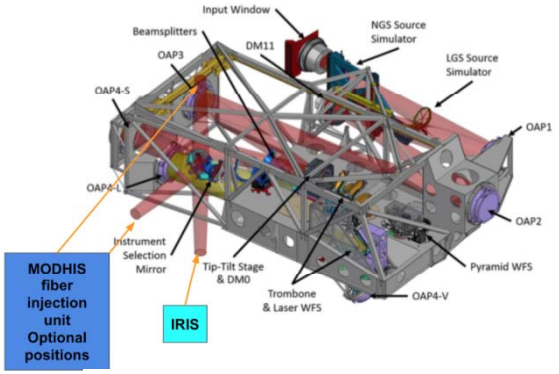
Common DM spec

Common DM (woofer)
- 120 x 120 actuators
- Stroke: 10um WF to correct for full TMT pupil
- Speed: 2 kHz
- actuator pitch: 1.5mm (pupil size 180mm diameter)

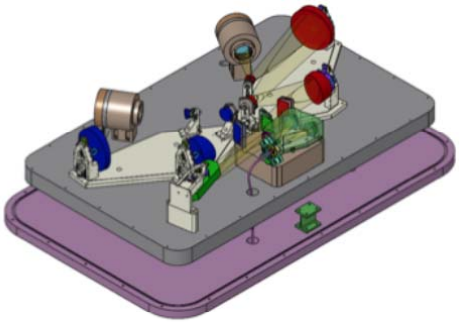
MODHIS as TMT 1st light exoplanet instrument

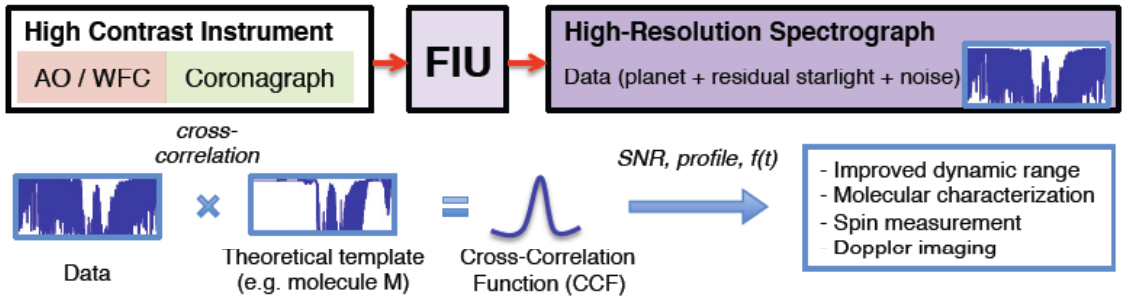
NFIRAOS
Strehl=0.3, 0.4, 0.5, 0.75 (Y,J,H,K)

Fiber Injection Unit
5x5 multi object



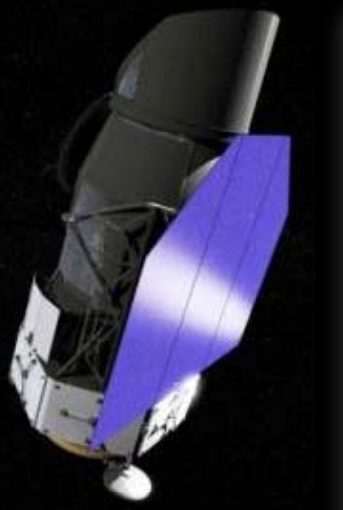
Spectrometer
0.95-2.5um, R=100,000

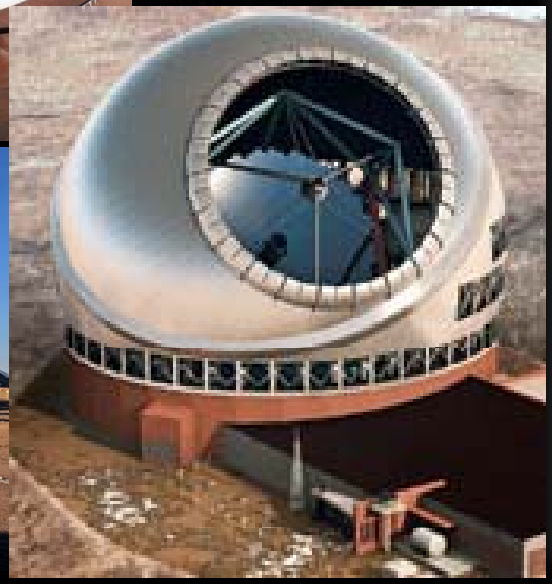




- 0.97-2.5um, R=100,000, mini IFU 5x5 NIR spectrometer
- Combined with AO (NFIRAOS), To be combined with PSI
- Single mode fiber-fed, so no modal noise and very compact (40x80x30 cm^3) instrument
- Successor (for TMT) of Keck/HISPEC and Subaru/IRD
- NIR-RV (10cm/s), CC spectroscopy, planet surface map

Summary





Dedicated exoplanet instruments will be critical for TMT even at its first light phase

↓

- MODHIS
- PSI (and MICHI thermal) in two phases

↓

Imaging & Spectroscopy of Temperate Rocky Exoplanets

Synergy with WFIRST/CGI

TMT and ALMA are in fact astrobiology telescopes.