Three fundamental aspects

1/ Formation/Architecture of planetary systems

2/ Physics of exoplanets

3/ Search for bio-signatures

1/ Formation/Architecture

. We do not know how giant planets form?

- Core accretion versus stellar-like mechanisms (GI)
- Gas accretion onto the proto-Giant planets (Hot vs Cold-Star models)?

. Dynamical evolution & stability?

- Planet – disk interactions (inward/outward migration)
- Planet – planet interactions (Fundamental for the Solar system formation)

. Even less knowledge on how rocky planets form?

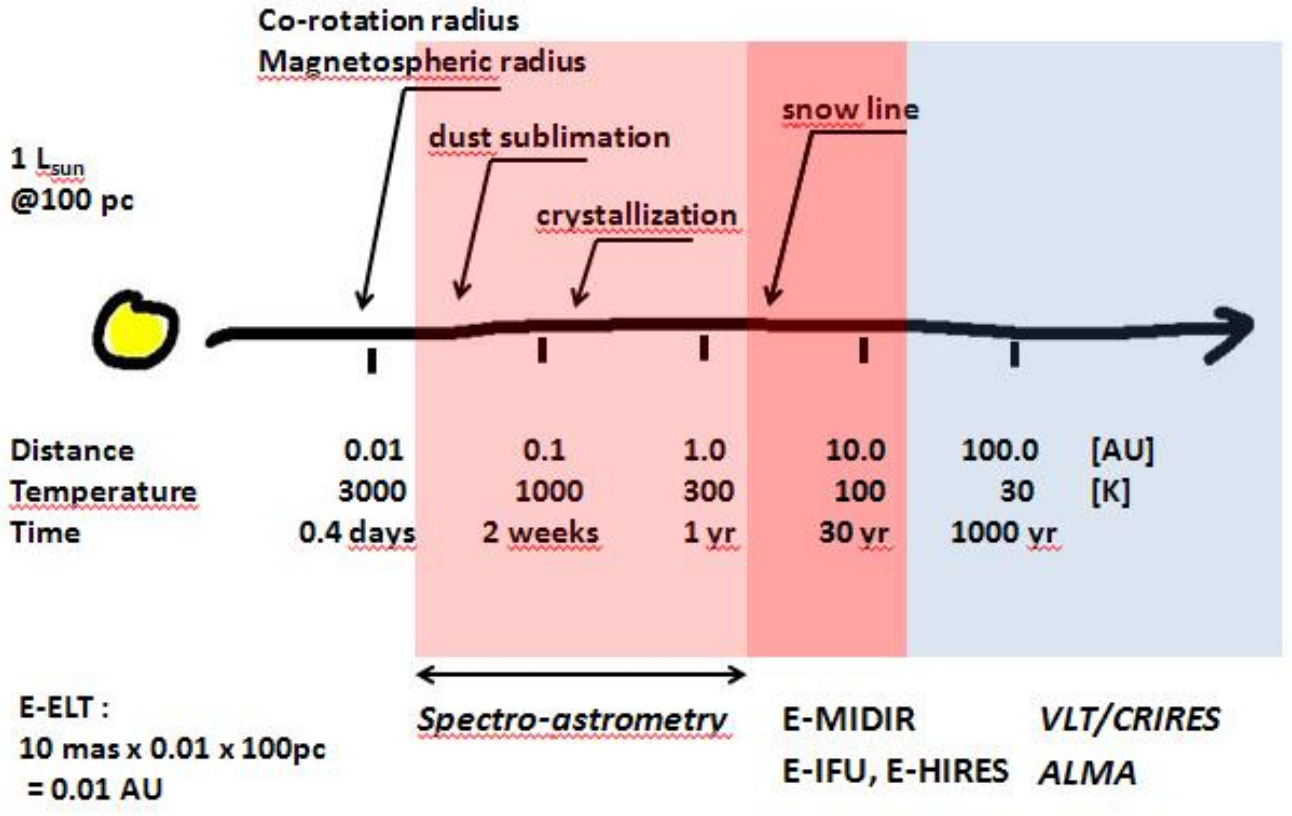
- Proto-planets collision afterglows

1. Limited view of the physical processes into the planet-forming zones
2. Incomplete view of the population of giant & rocky planets at all separations, for different stellar hosts, at different evolutionary stage...

1/ Formation/Architecture

1. Access the planet-forming zones (L. Testi)

- Grain growth, Gas/Dust co-evolution and chemistry, Disk evolution...
- **synergy**: - Other facilities: ALMA, SKA, VLTI, JWST
  - EELT instruments: HARMONI, HIRES, METIS, PCS…
  - Observation – Theory: setting initial conditions

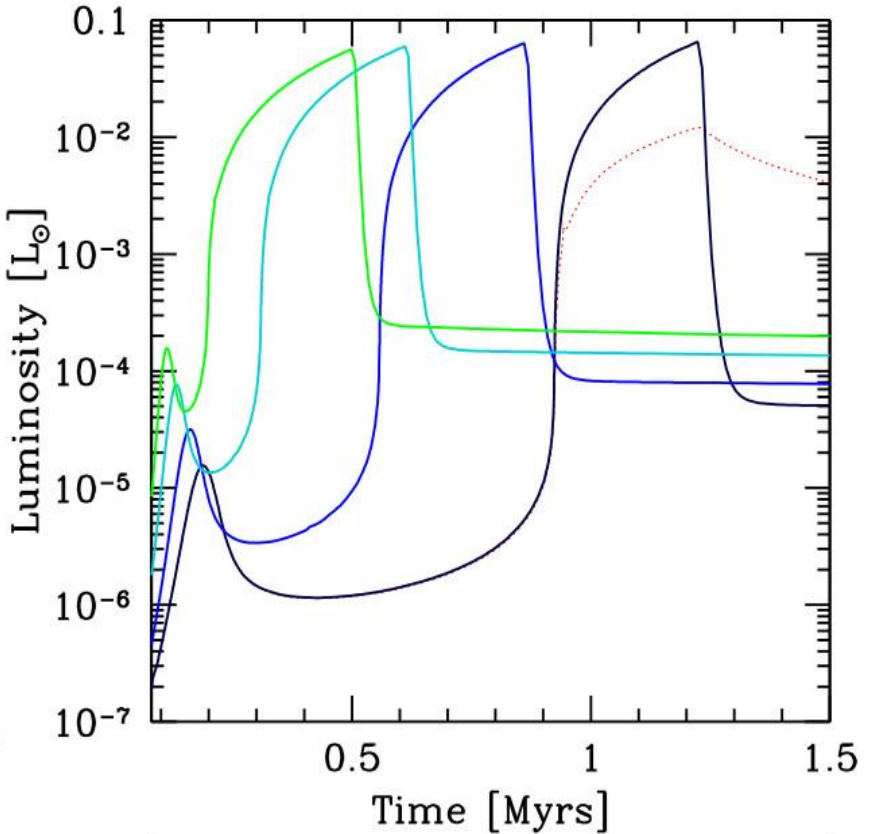


1/ Formation/Architecture

1. Access the planet-forming zones (M. Meyer)

- Proto-planets detection/characterization
- Planet – disk interactions, accretion processes
- **synergy**: - EELT instruments: METIS

  - Observations – Theory: direct tests for planetary formation theories



1/ Formation/Architecture

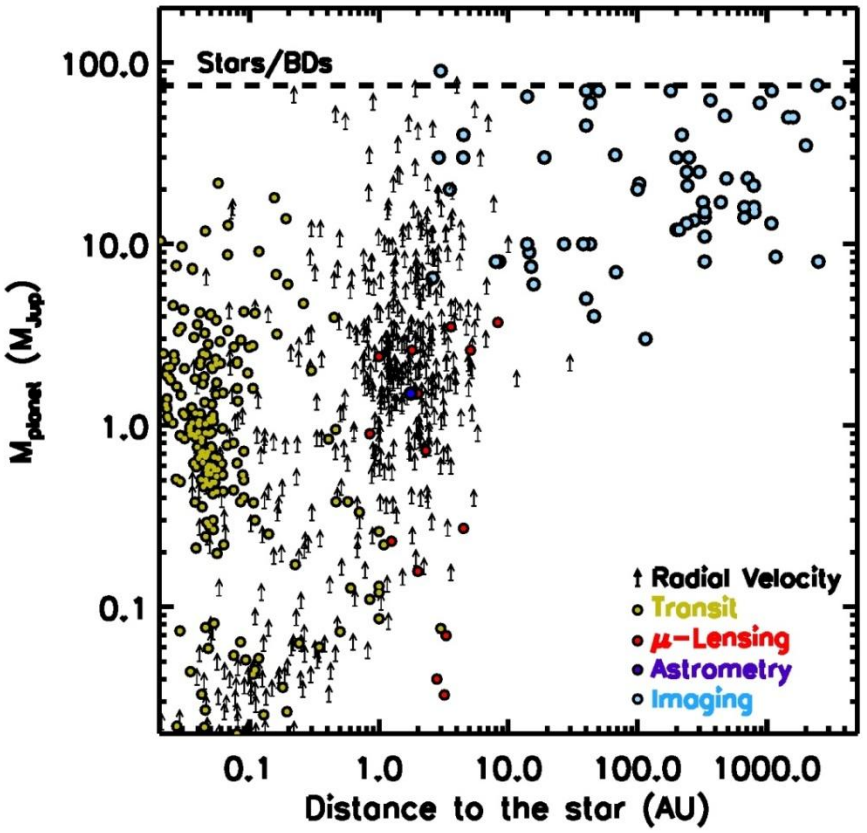
2. Incomplete view of the population of giant & rocky planets

at all separations, for different stellar hosts, at different evolutionary stage.

> Statistics on occurrence and distributions of giant planets (A. Boccaletti; B. Biller)

synergy: - Current/future facilities, RV, GAIA, Kepler, TESS... and EELT

- Observations – Theories: occurrence & distribution



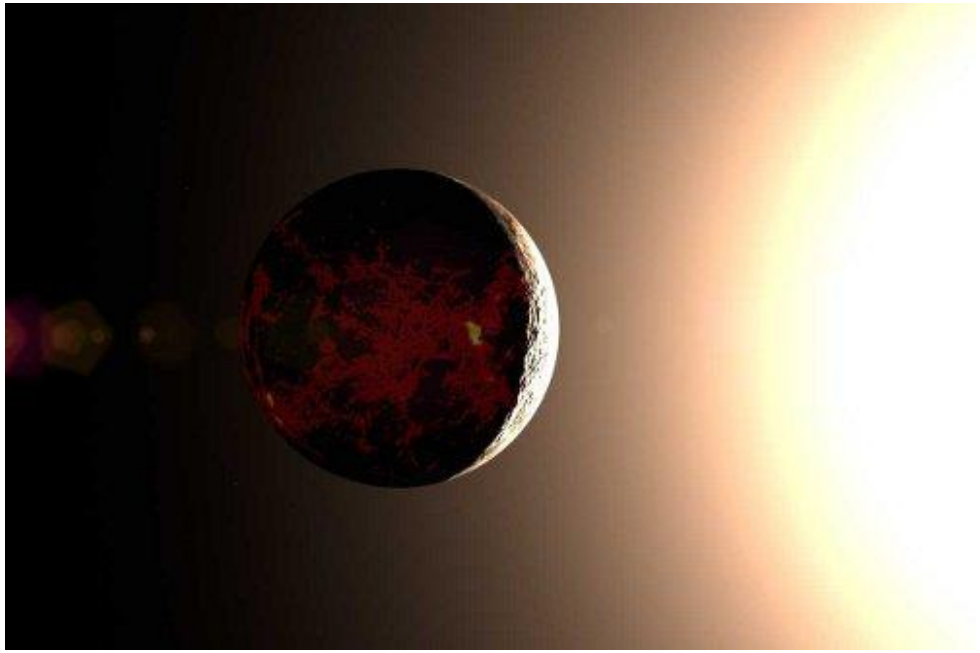
2/ Physics of Exoplanets

. Limited knowledge on the planetary structures & atmospheres

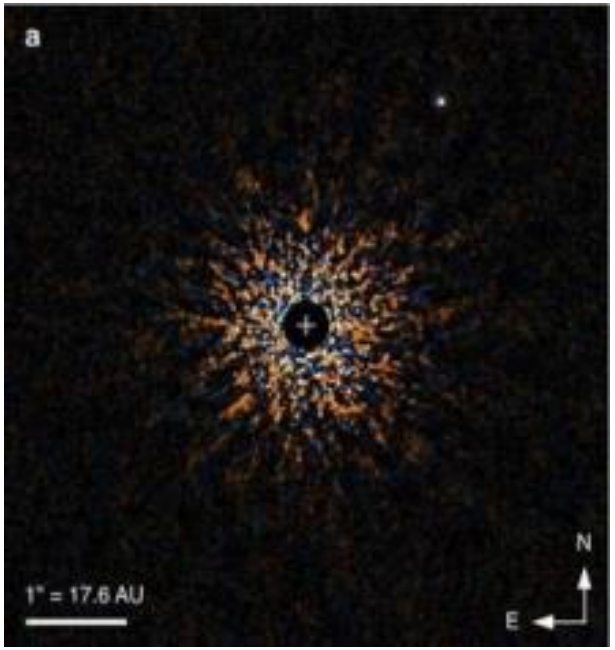
of giant & rocky planets

- Wide range of physical conditions: strongly irradiated to non-irradiated, high to low densities, proto- to evolved planets, evaporating planets... (M. Janson; I. Crossfield)

Alpha Cen Bb
1.15 Mearth, 1500K, 0.04AU



GJ504 b
MJup, 510K, 43AU



2/ Physics of Exoplanets

. Limited knowledge on the planetary structures & atmospheres

of giant & rocky planets

- Wide range of physical conditions: strongly irradiated to non-irradiated, high to low densities, proto- to evolved planets, evaporating planets...
- Limited number of observables/planet: Mass, radius, luminosities, orbital characterization (a, e, i...), misalignment, atmosphere properties...
- Impact of clouds: How common? Range of albedos? Composition? (B. Demory)
- Important degeneracy in the interior & atmosphere models
- Composition , chemistry, temporal evolution (Doppler imaging; I. Crossfield)

Synergy: - with other facilities: RV, Transit, HDS, HCI, GAIA…

- EELT instruments: techniques, wavelengths, resolution,

(HARMONI, MICADO, METIS, HIRES….MOS, PCS)

- Observations & Theories: Structure, atmospheres...

2/ Physics of Exoplanets

C. Lovis

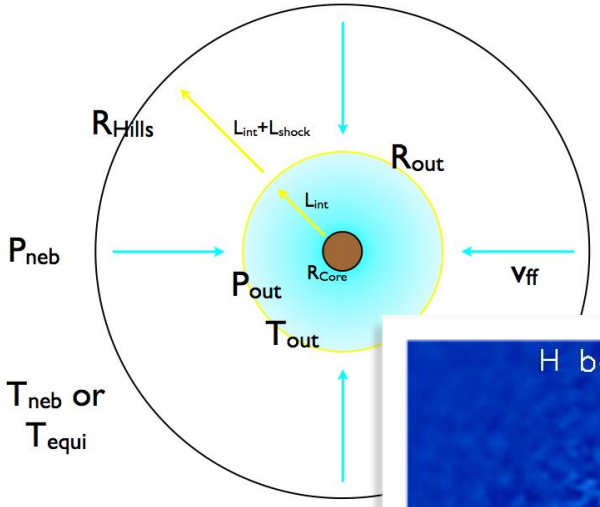
Property of Interest	*Available Technique*
High-precision stellar properties: mass, radius, Teff, age, [Fe/H], abundances of various elements	High-resolution spectroscopy, long-baseline interferometry, high-precision astrometry (GAIA)
Binarity or multiplicity of the host star	Direct imaging, long-term Doppler velocimetry, astrometry (GAIA)
Existence and properties of debris disks	High-contrast imaging, interferometry
Orbital properties of all dynamically important planets in the system	High-precision transit photometry, long-term Doppler velocimetry, astrometry (GAIA), high-contrast imaging
Mass and radius (→ density, bulk composition) of the dynamically important planets	High-precision transit photometry, Doppler velocimetry, astrometry (GAIA)
Atmospheric characterization of one or more planet(s)	Transit/eclipse spectrophotometry, high-resolution spectroscopy, high-contrast spectroscopy

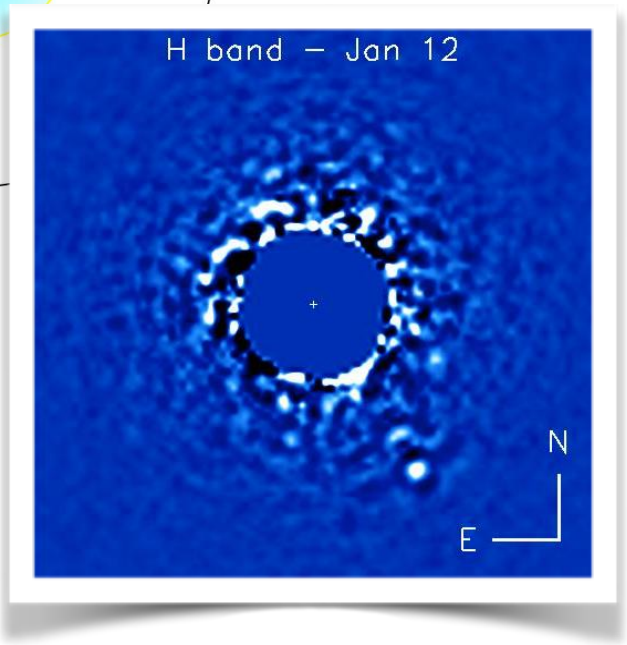
2/ Physics of Exoplanets

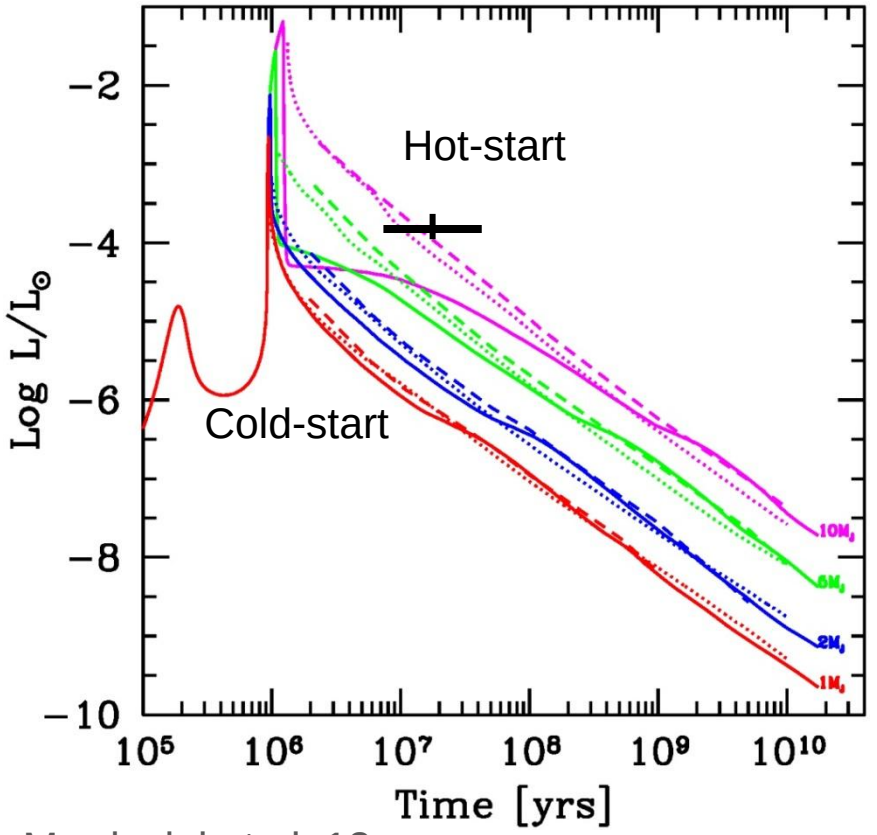
. Limited knowledge on the planetary structures & atmospheres

of giant & rocky planets

. Synergy example: Dynamical mass of Young Jupiters (RV/GAIA and HCI)







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3/ Biomarkers detection

. A revolutionary science case for the EELT

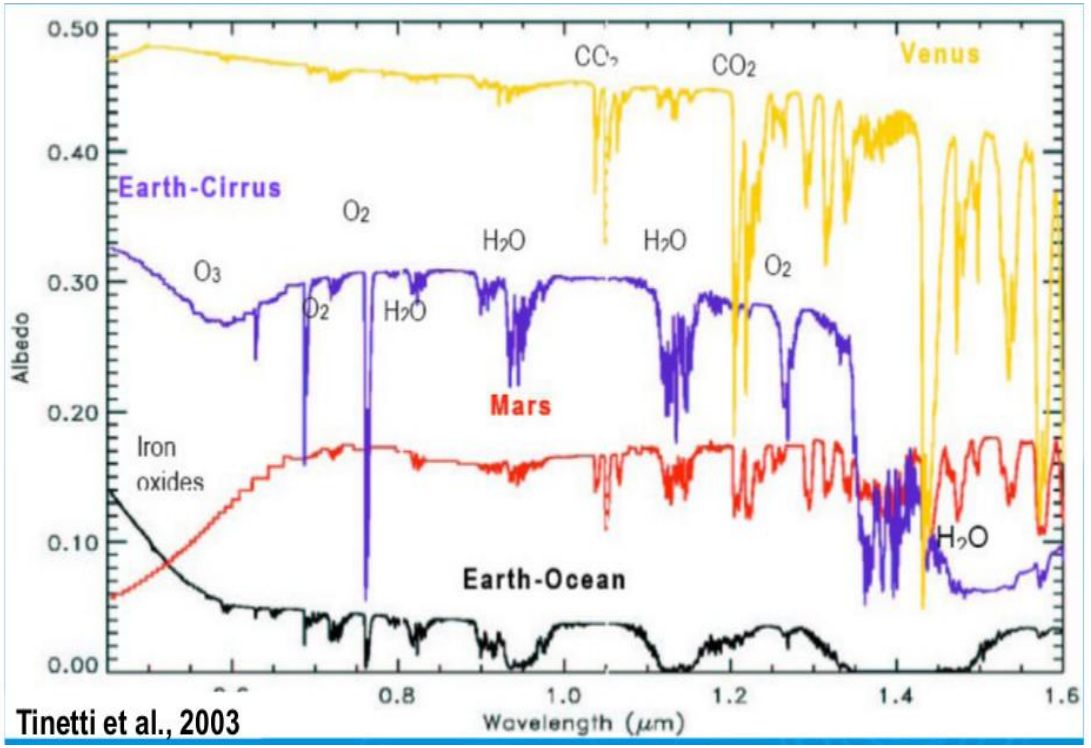
• EELT will arrive after a decade of HZ planets surveys,

• JWST will prepare EELT science with low-res spectra of HZ planets,

. Synergy: - Facilities (JWST, RV, transit...): Target identification

- Techniques: HCI + HDS, the way to go?

- Theory/Simulations: Astronomer / Biologists?



Questions

1. Formation/Architecture

Q: What role with VLTI and other interferometers play in the next decade?

Q: Interplay with VLT instruments: *ESPRESSO*, ERIS (pre-cursor for METIS?)…?

Q: Interplay with the GAIA community?

Q: What tests could allow to distinguish btw planet formation by CA & GI?

Q: In-depth studies of a limited population of stars vs general surveys according to the different techniques (HCI, HDS, RV...)?

Q: How to optimally combine detection limits from different techniques?

Q: EELT Roadmap for Formation/Architecture: MICADO, HARMONI, METIS, PCS?

Questions

2. Interior/Atmosphere of exoplanets?

Q: Are HCI and HDS the main atmosphere characterization techniques for E-ELT.

Is there a gain in observing a reference star with HDS for ultimate performances?

Q: Is EELT-MOS low-res transmission spectroscopy of low-mass planets around

M dwarfs (~10mag) Interesting or not? respect to JWST?

Q: If yes, Fiber-fed IFUs or slitless concept for EELT/MOS?

Q: Interplay with interior/atmosphere theoreticians (HRS lines, molecular database, ….)

Q: Mission reference sample for rocky planets characterization: nearby M dwarfs?

Q: EELT Roadmap for atmosphere characterization: HARMONI, HIRES, METIS, PCS?

Questions

3. Biomarkers detection

Q: HCI+HDS ultimate performances? Speckles interplay subtraction and HDS?

Q: Which is the instrument for biomarkers discovery; METIS, PCS or EELT-6?

>> Instrumental roadmap for biomarkers!

Q: Best biomarkers probed by the EELT?

Q: Broader community? Synergy btw Astronomers and exo-biologists?

Q: EELT Roadmap for Biomarkers: HIRES, METIS, PCS

4. Others:

Q: What about an IFU in N-band for METIS? Q-band? For exoplanetary science?

Q: Shall we already identify SWGs: i/ Exoplanets with 1st Light instruments, ii/ contrast metric and assumptions for HCI, iii/ fiber-fed IFU versus slitless spectroscopy and science driven (formation/architecture, exoplanet physics and biomarkers)