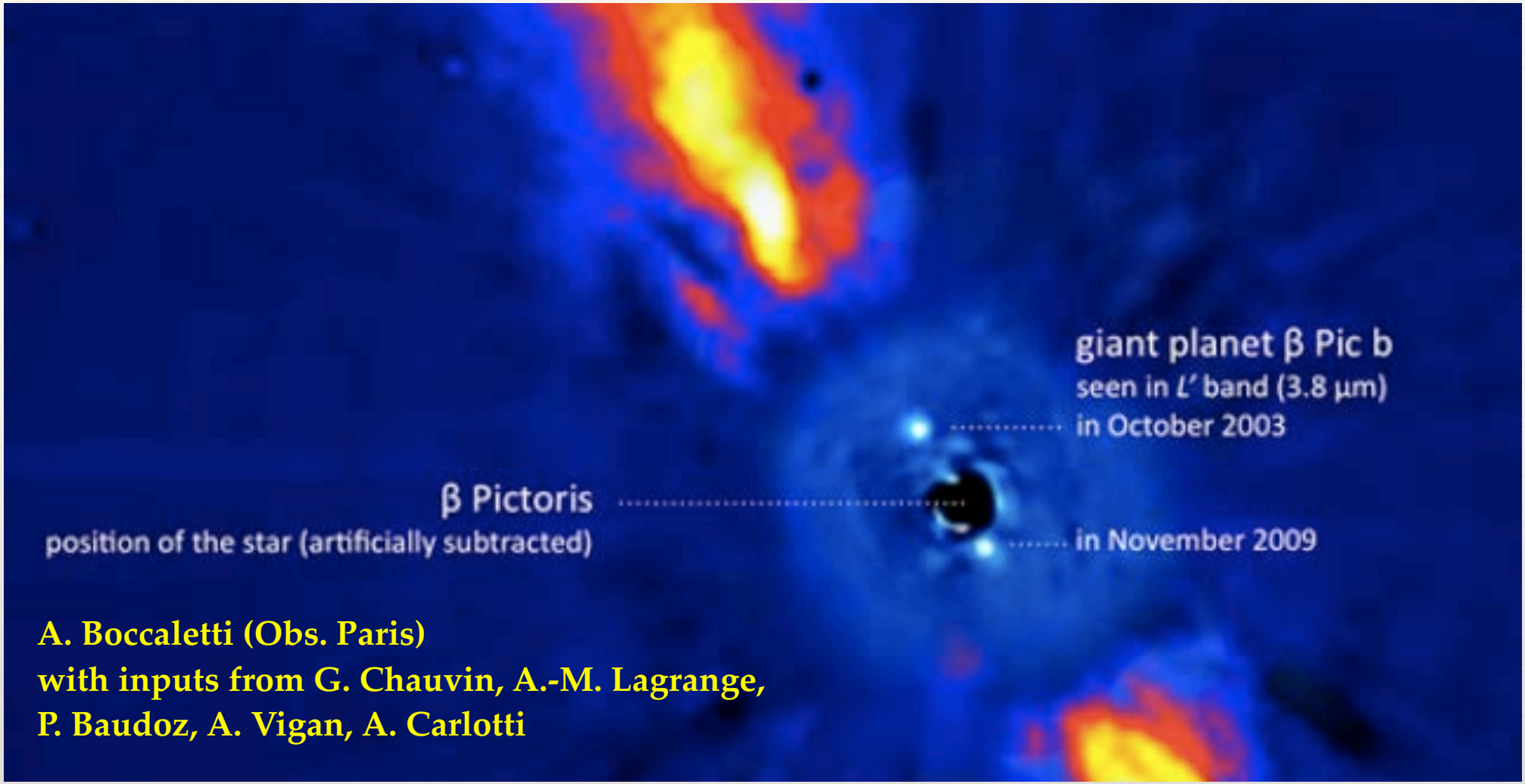
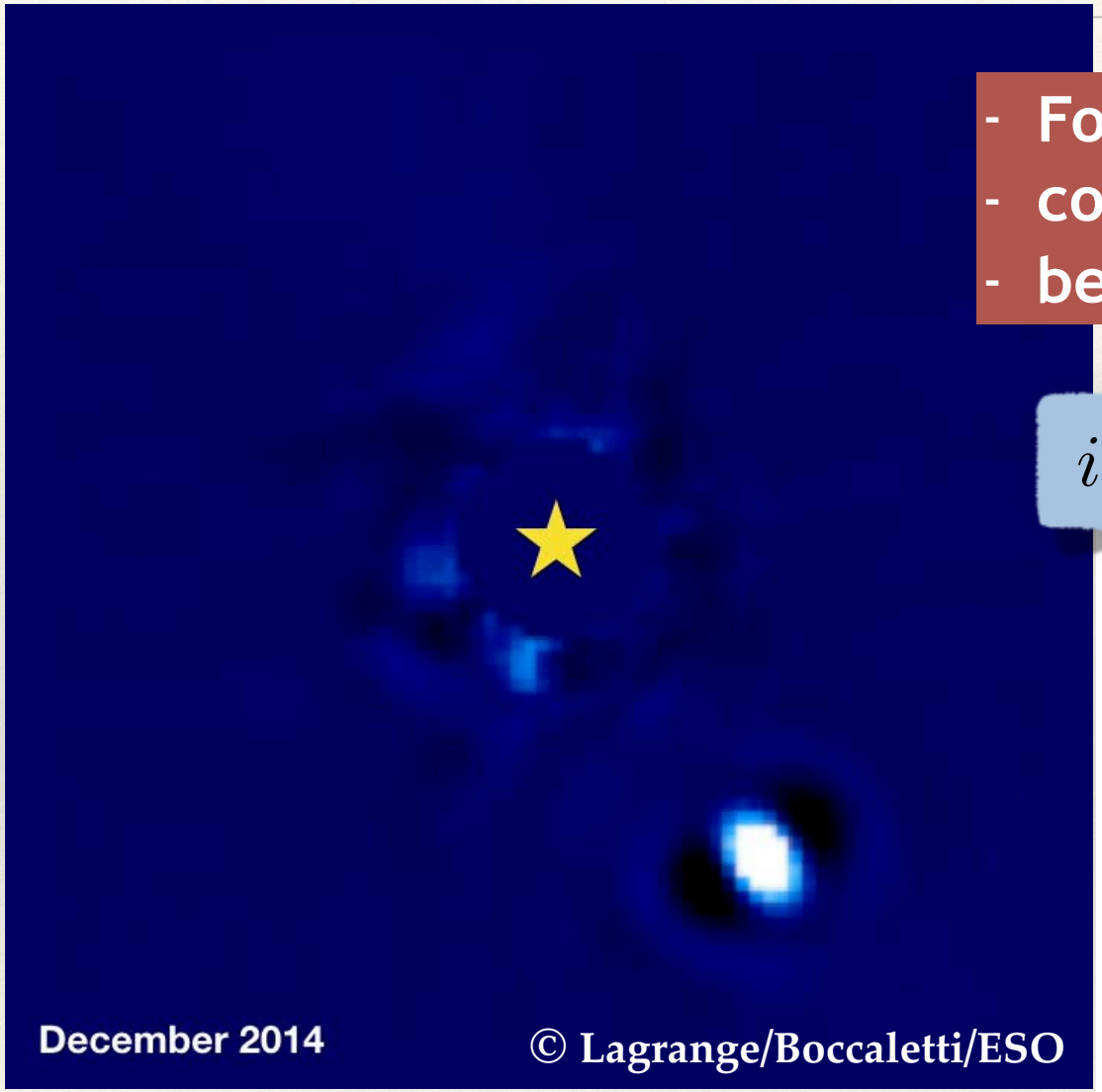


A. Boccaletti (Obs. Paris)
with inputs from G. Chauvin, A.-M. Lagrange, P. Baudoz, A. Vigan, A. Carlotti

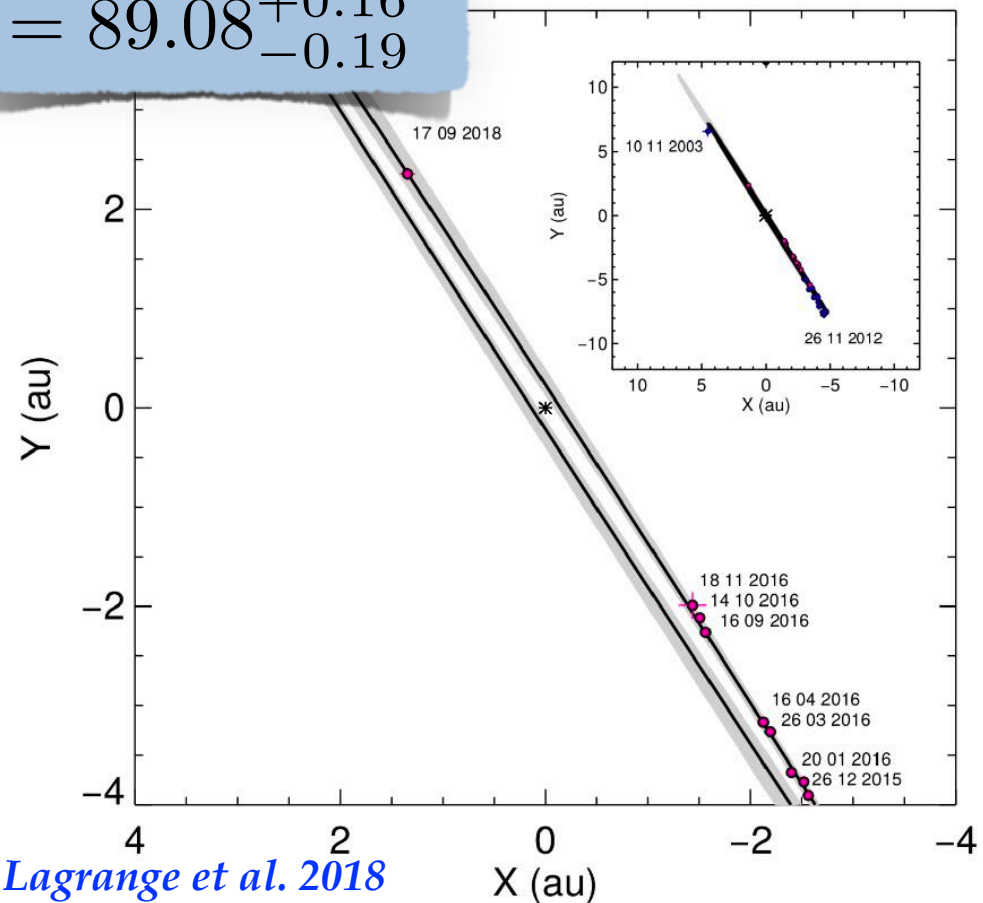
Synergy Imaging - Transit

A school case



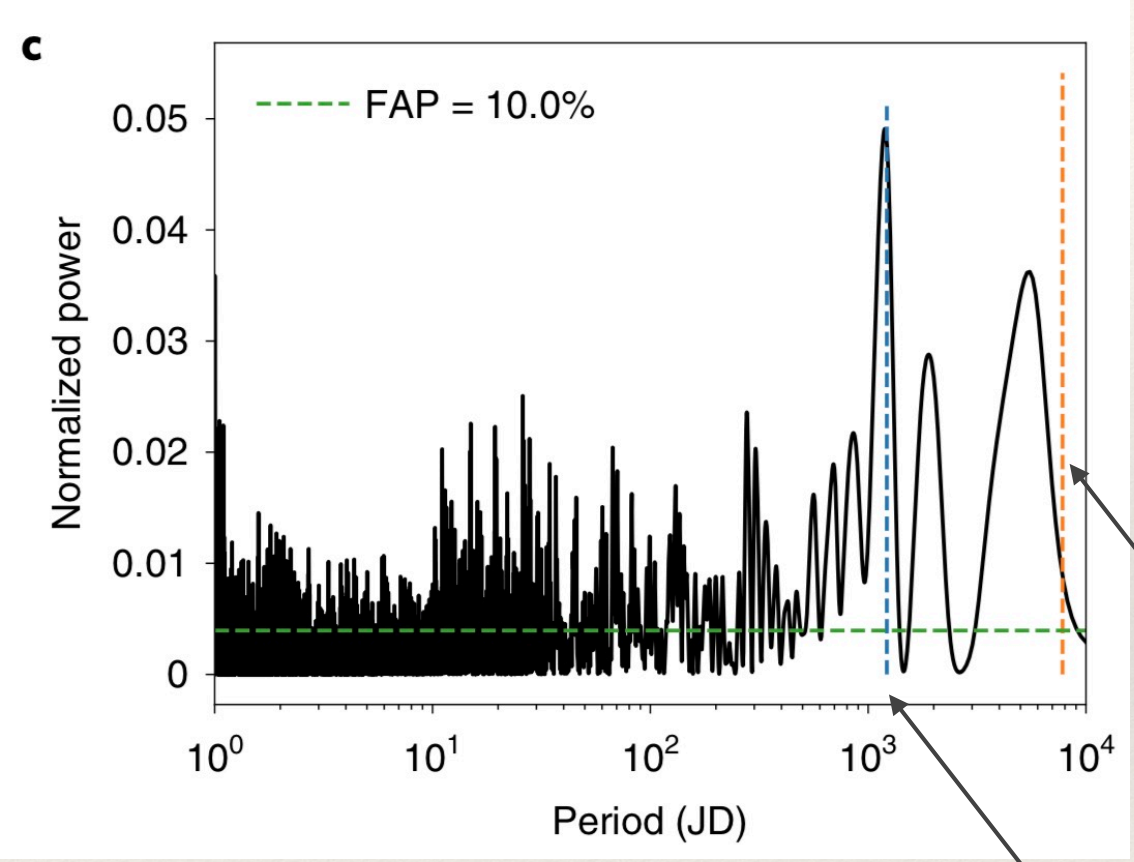
- Follow up since 2003
- conjunction in Sept. 2017
- beta Pic b is NOT transiting

$$i = 89.08^{+0.16}_{-0.19}$$



Lagrange et al. 2018

A school case



Lagrange et al. 2019

- Evidence for beta Pic c
- is it transiting ?

target of interest for JWST and ARIEL

beta Pic b : 7800d

beta Pic c : 1200d

Area of Synergies

Detection

- Observe the very same systems (full characterization of planets)
- Derive **false positive** in Transit
- Provide **targets** for Direct Imaging : more distant planets, case of CVSO30 (Schmidt et al. 2016) + ongoing SPHERE program (Desidera et al.)

Characterization

- Develop tools for s**pectral characterization** of warm exoplanets atmosphere

Diverging survey strategies

- Transit => low mass stars, short periods to access HZ, **telluric planets population**
- Imaging => young/early type stars, long periods, **giant planet population**

But …. **PLATO** could provide planets in **1-2 au orbits**

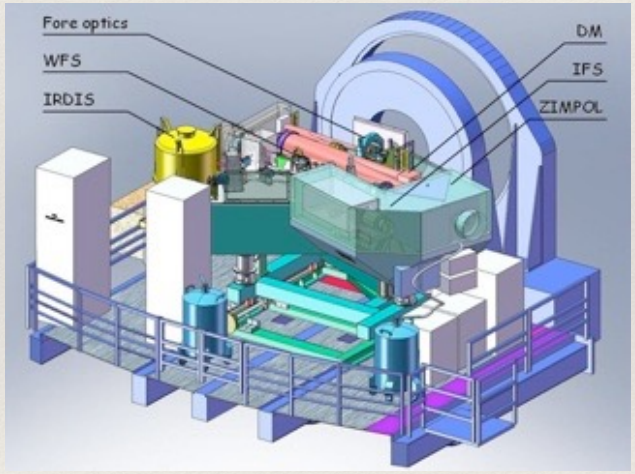
and …. **future imaging facilities** will start to dig into the **< 5-10 au** region

Current facilities

SPHERE
Spectro-Polarimetric High-contrast Exoplanet REsearch

European Consortium, VLT

- IR camera
- IR spectrograph
- Visible high precision polarimetrer



SCExAO

Japan, Subaru

- camera IR
- polarisation IR

MagAO

US, Chile

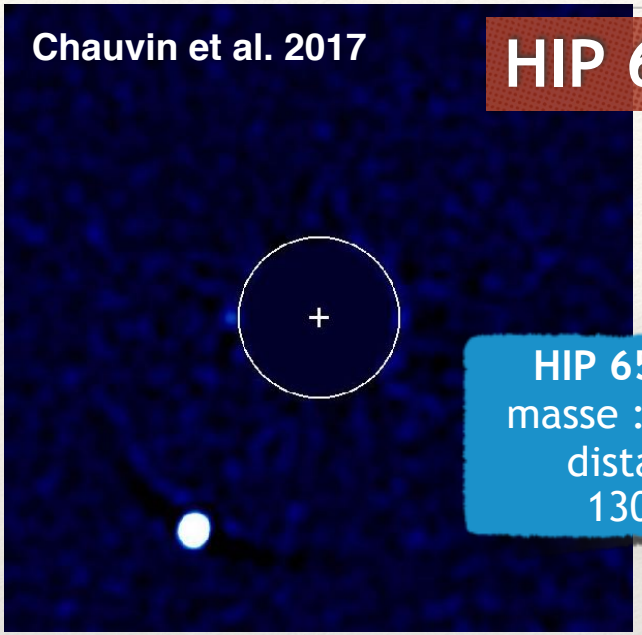
-camera visible

gpi

US, Gemini South

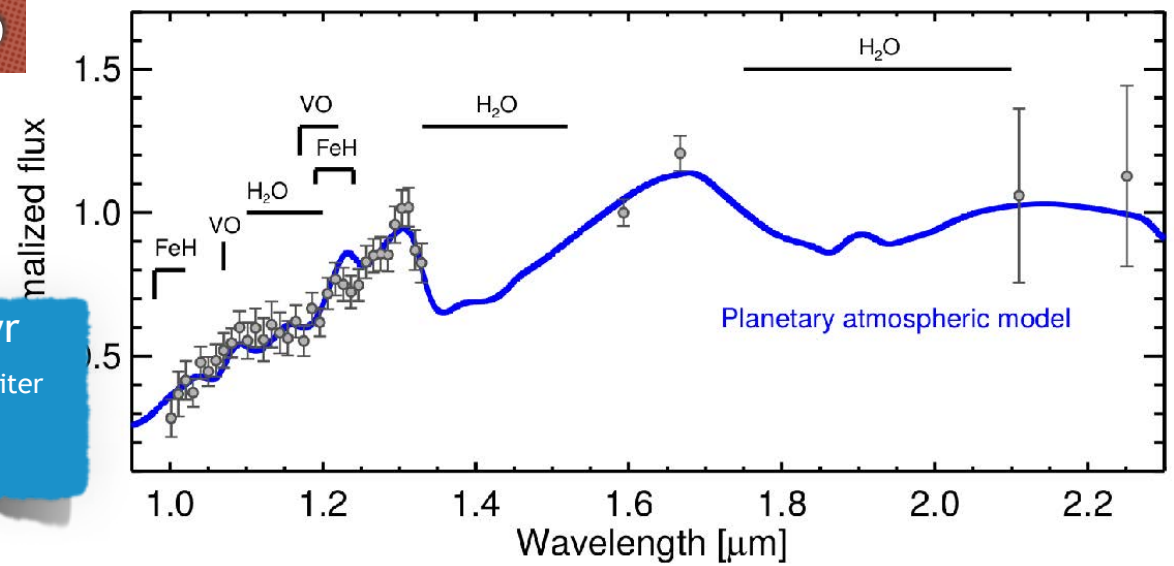
Spectrographe IR

Discoveries of super-Jupiter planets

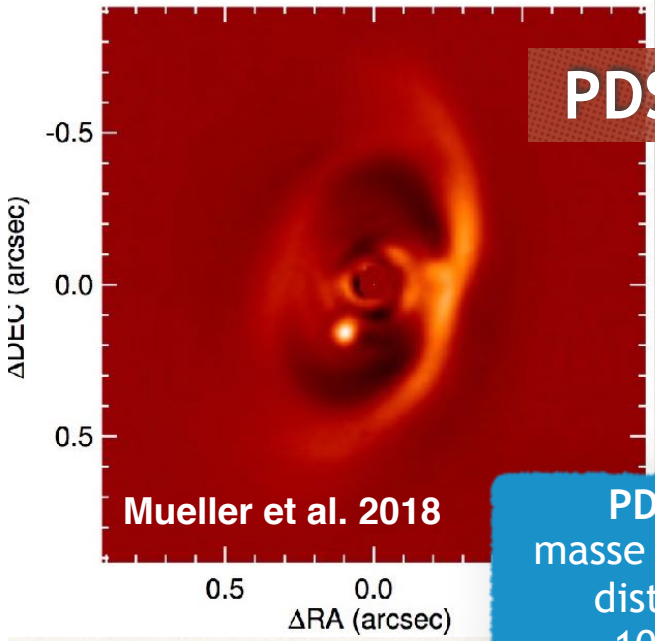


HIP 65426 b

HIP 65426 : 17 Myr
masse : ~ 6 -12 $M_{Jupiter}$
distance : 92 AU
1300 - 1600 K

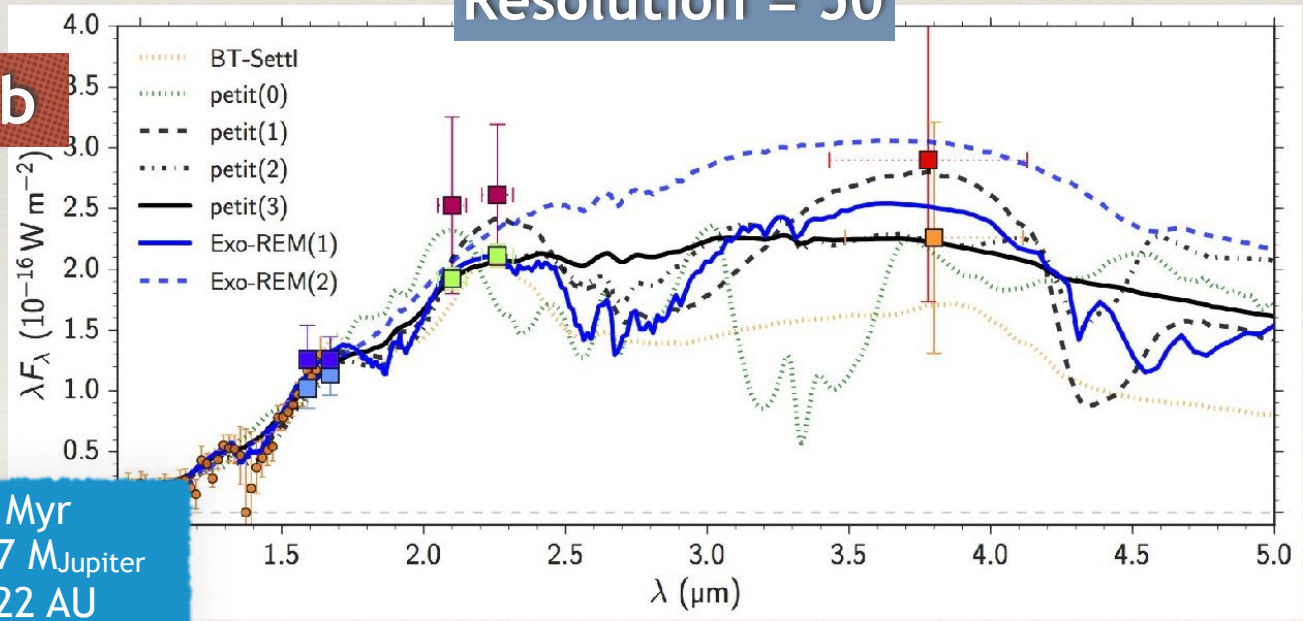


PDS 70 b



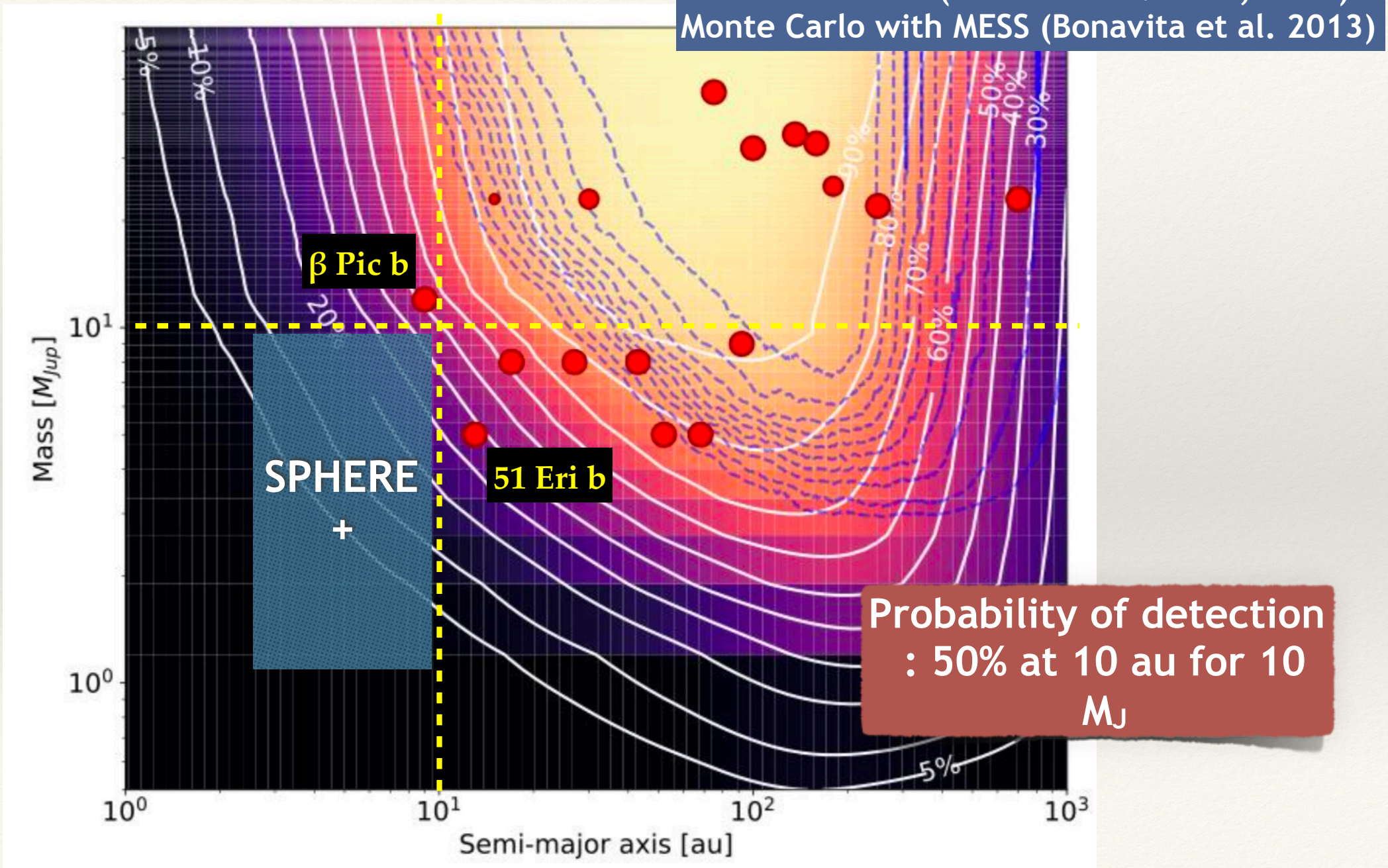
PDS 70: 5 Myr
masse : ~ 2 -17 $M_{Jupiter}$
distance : 22 AU
1000 - 1600 K

Resolution = 50



Current Performance

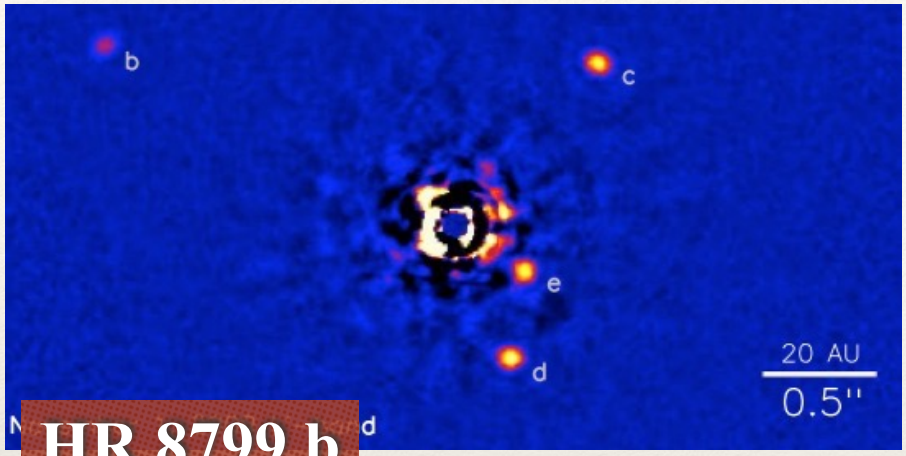
Mass conversion (Baraffe et al. 2003, 2015)
Monte Carlo with MESS (Bonavita et al. 2013)



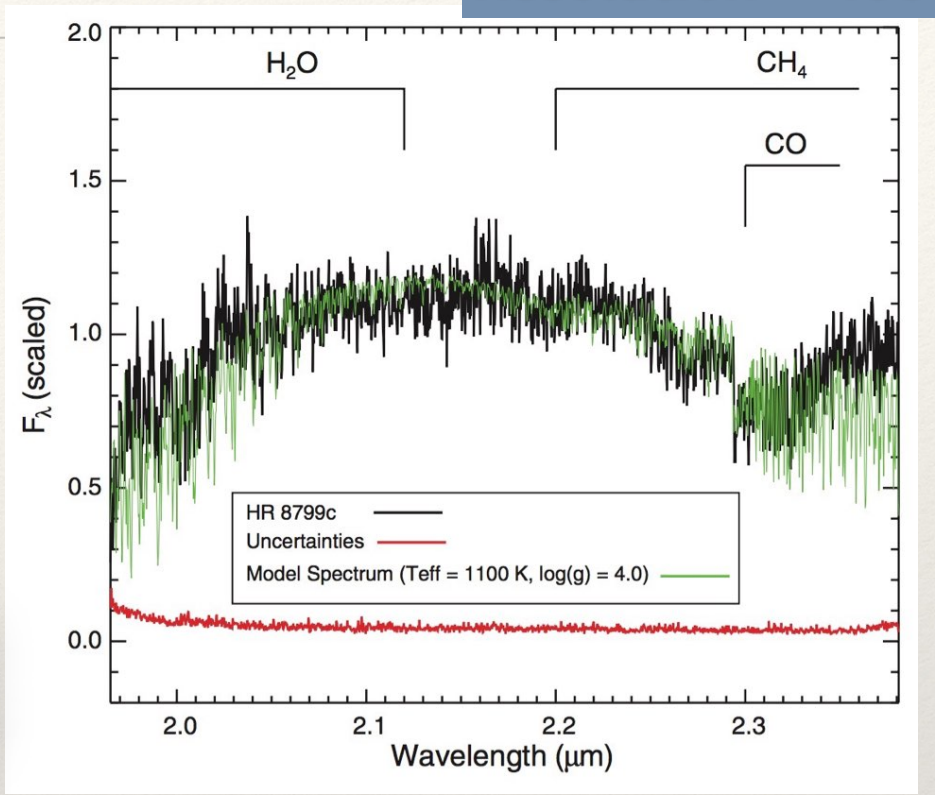
Probability of detection : 50% at 10 au for 10 M_J

Medium resolution

Resolution = 400



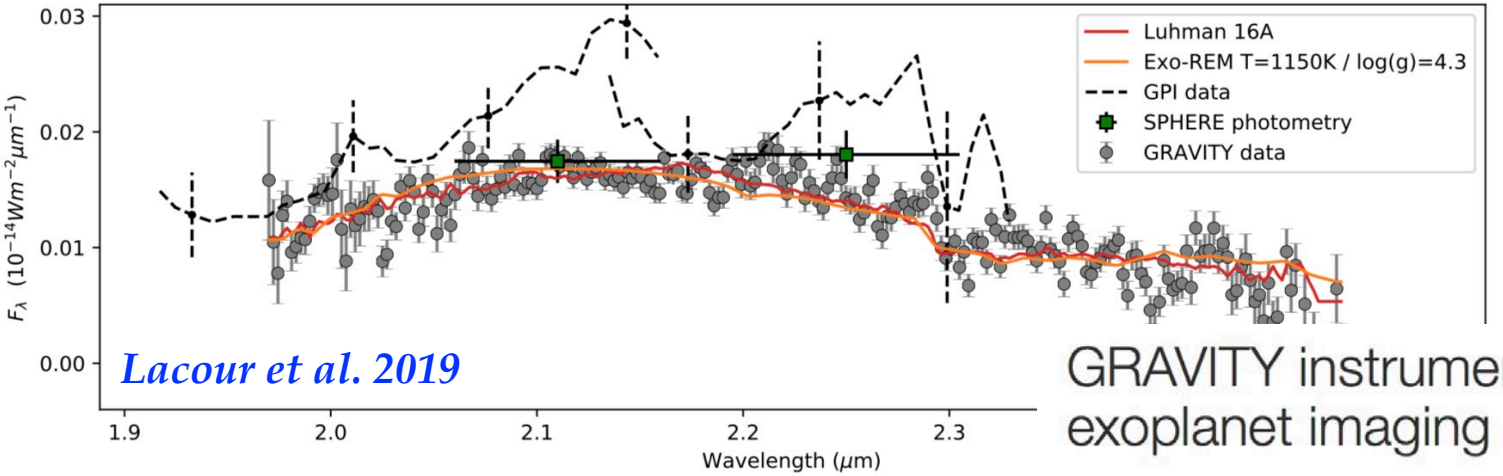
HR 8799 b



priority of SPHERE+ to achieve R=1000-5000

Resolution = 500

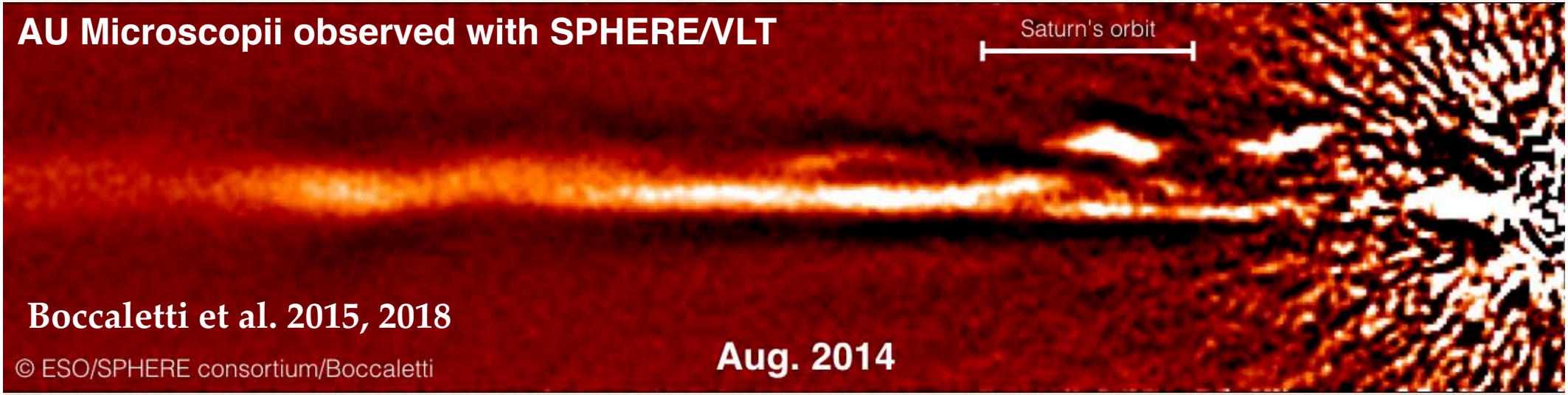
Konopacky et al. 2013

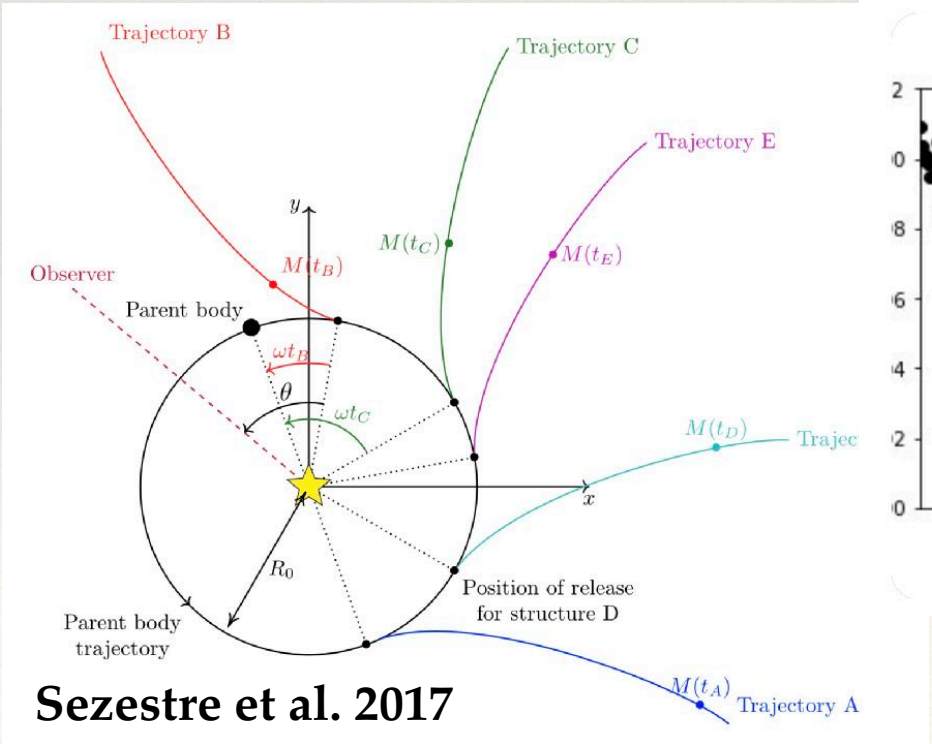


Lacour et al. 2019

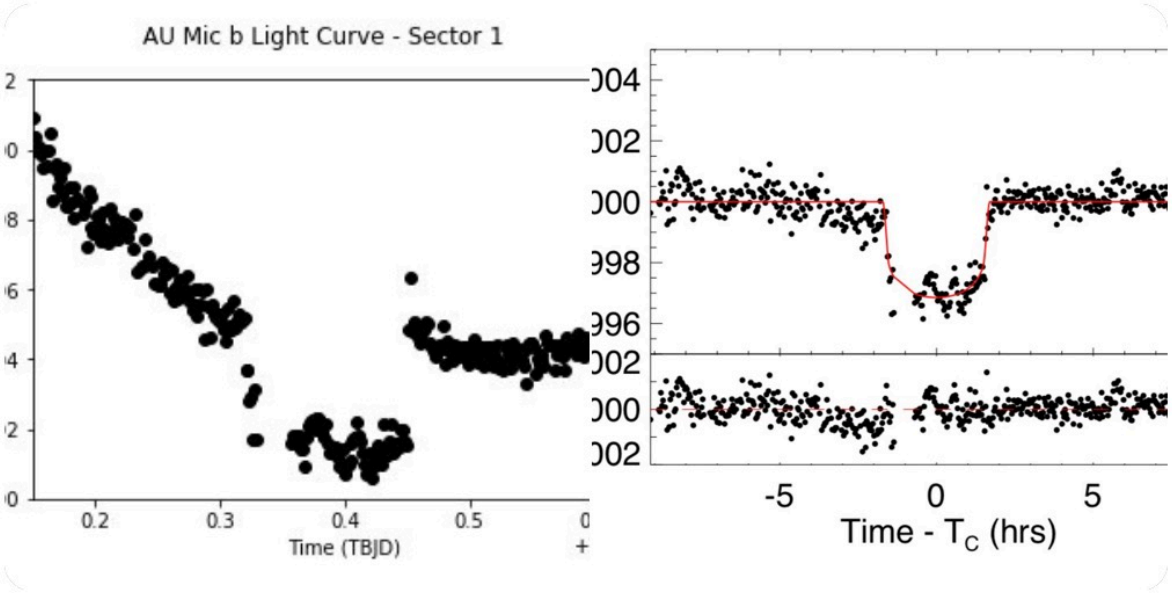
GRAVITY instrument breaks new ground in exoplanet imaging

Synergy disks/planets



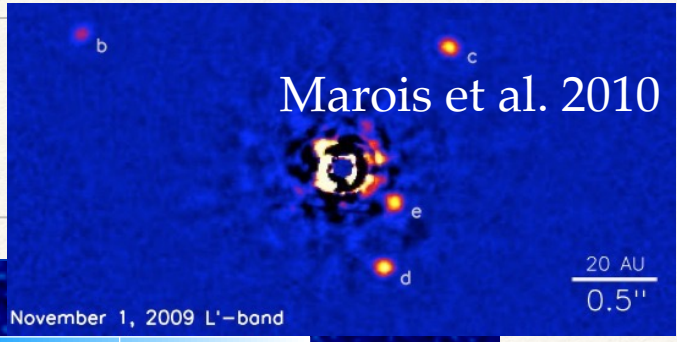


Sezestre et al. 2017



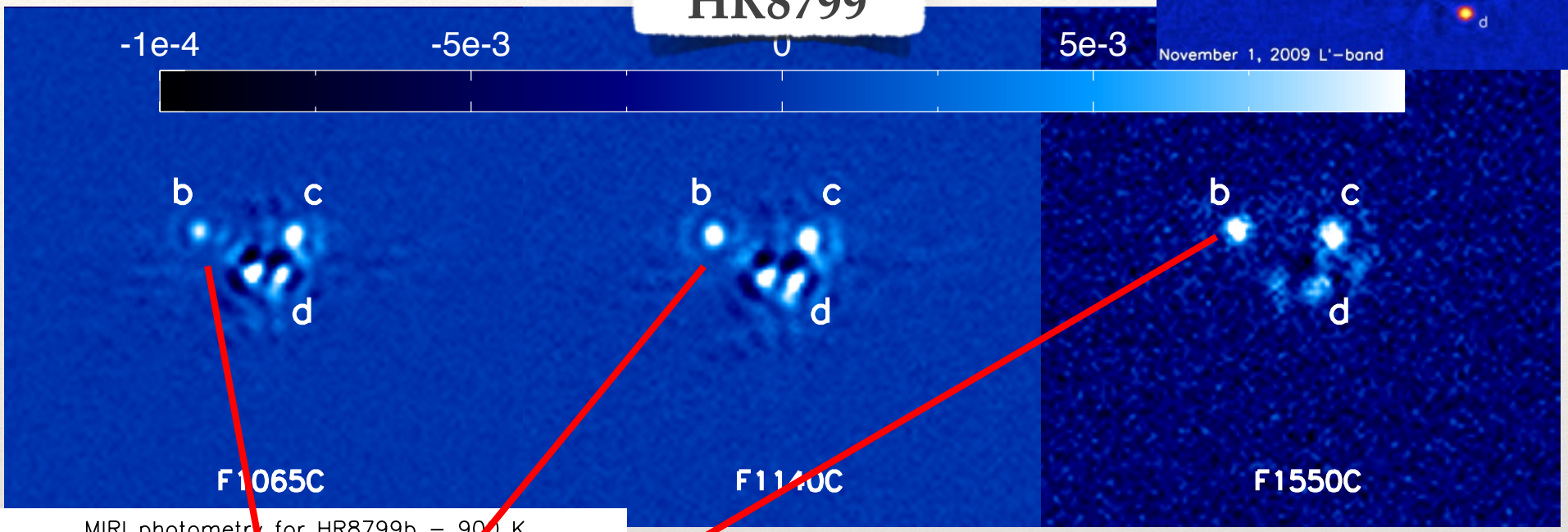
Plavchan 2018, Twitter….

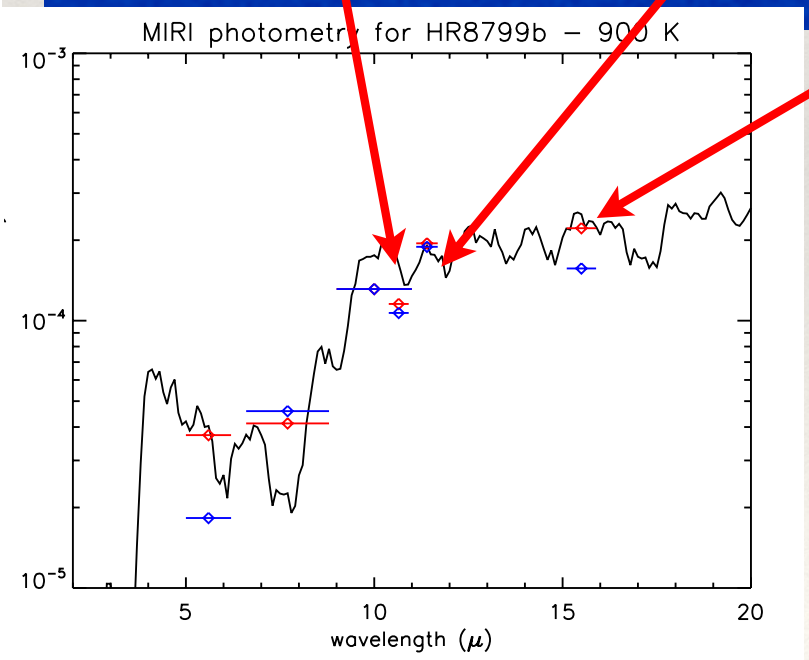
JWST/MIRI

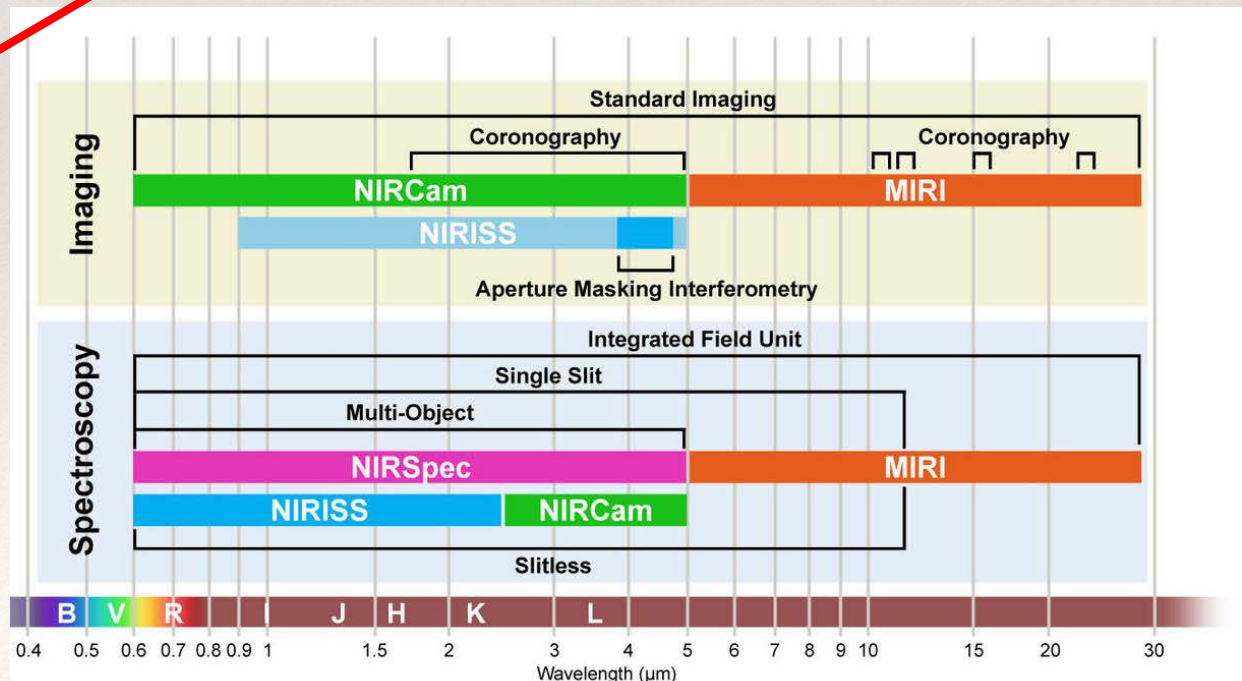


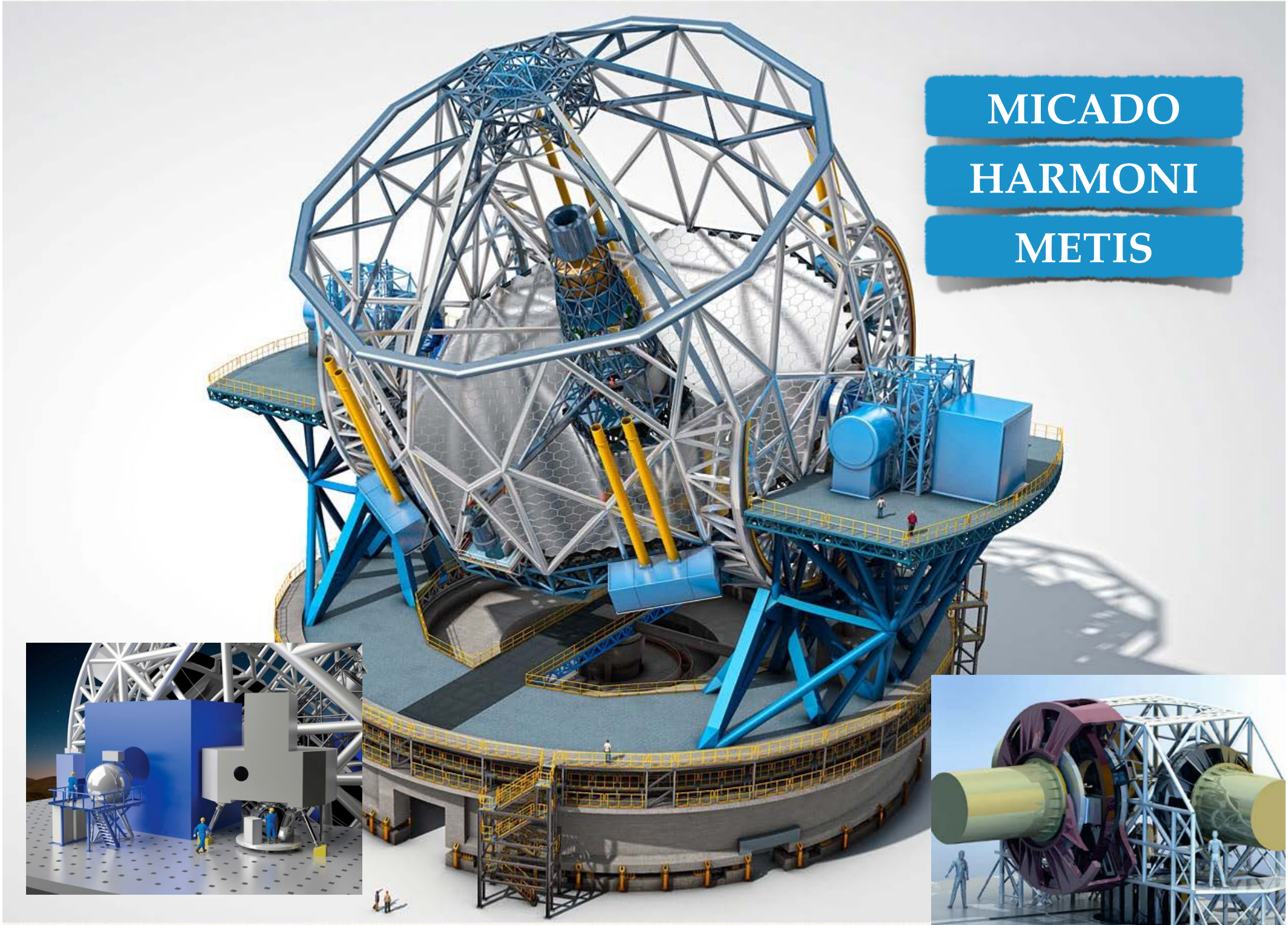
Marois et al. 2010

HR8799

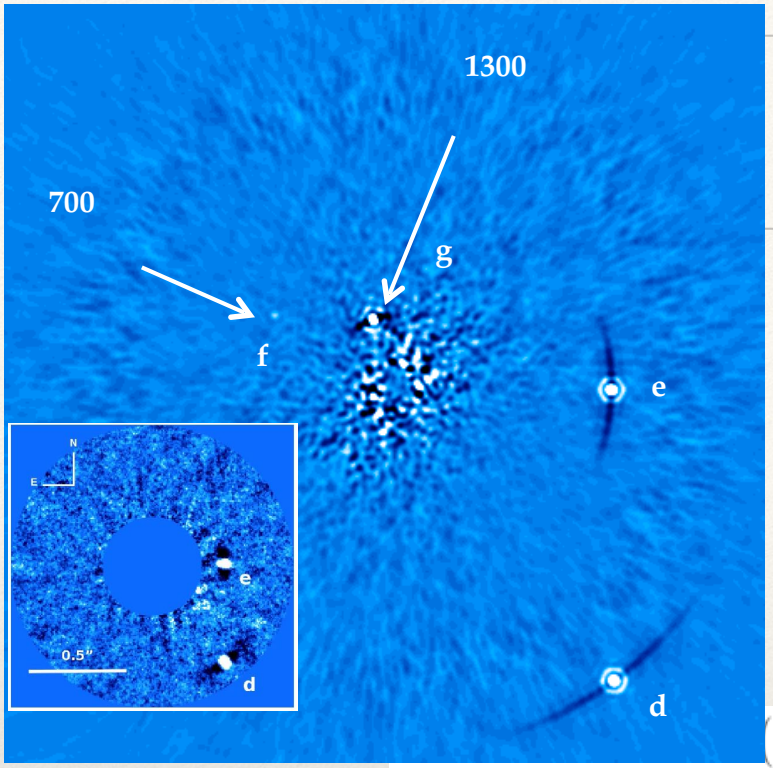


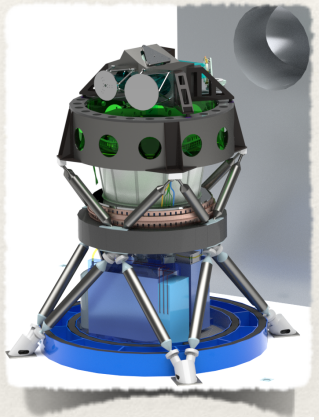


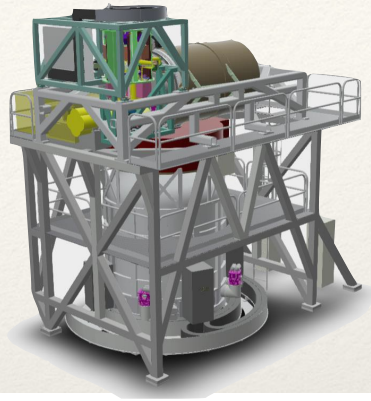


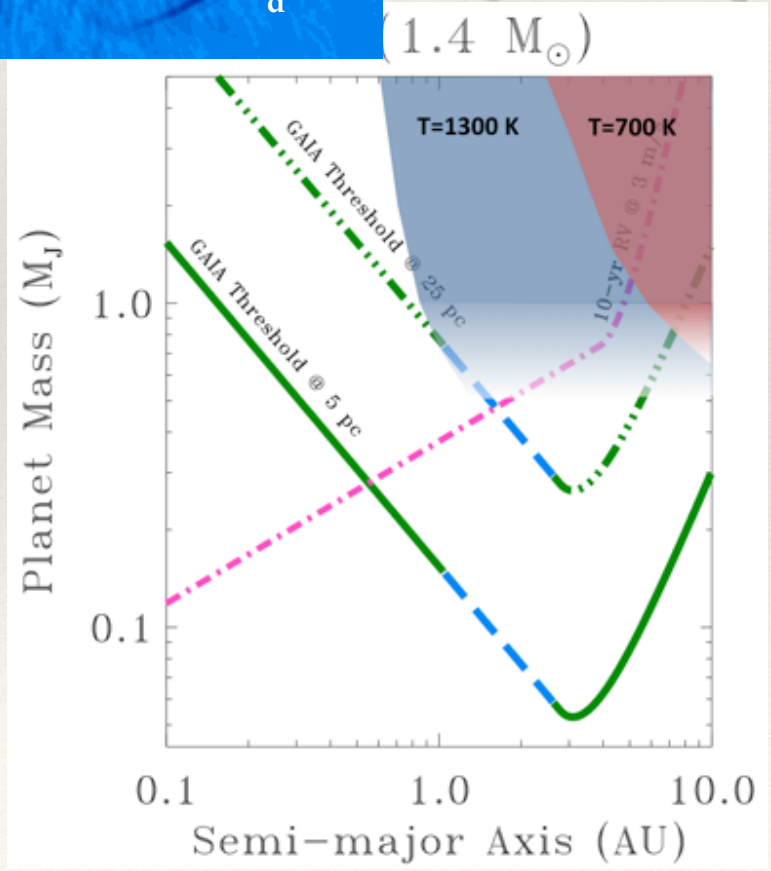

MICADO
HARMONI
METIS

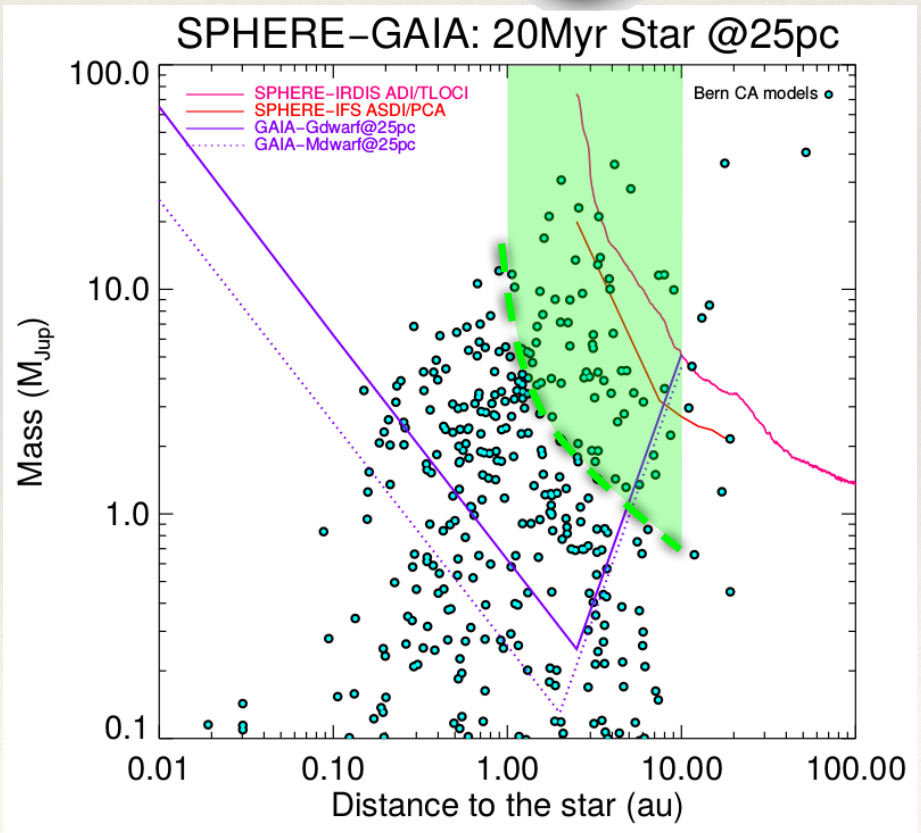
MICADO / HARMONI







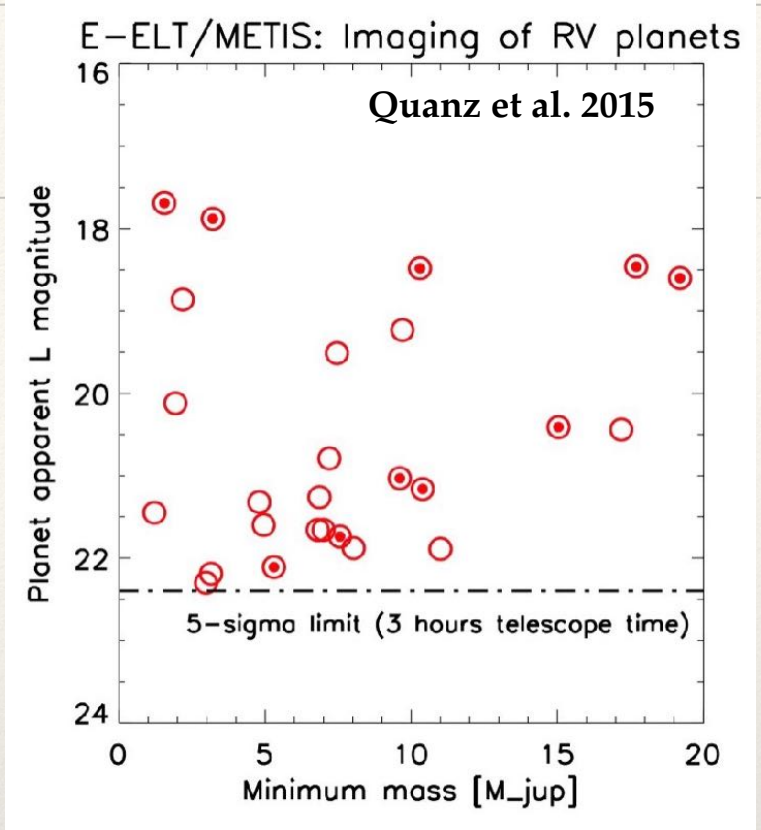




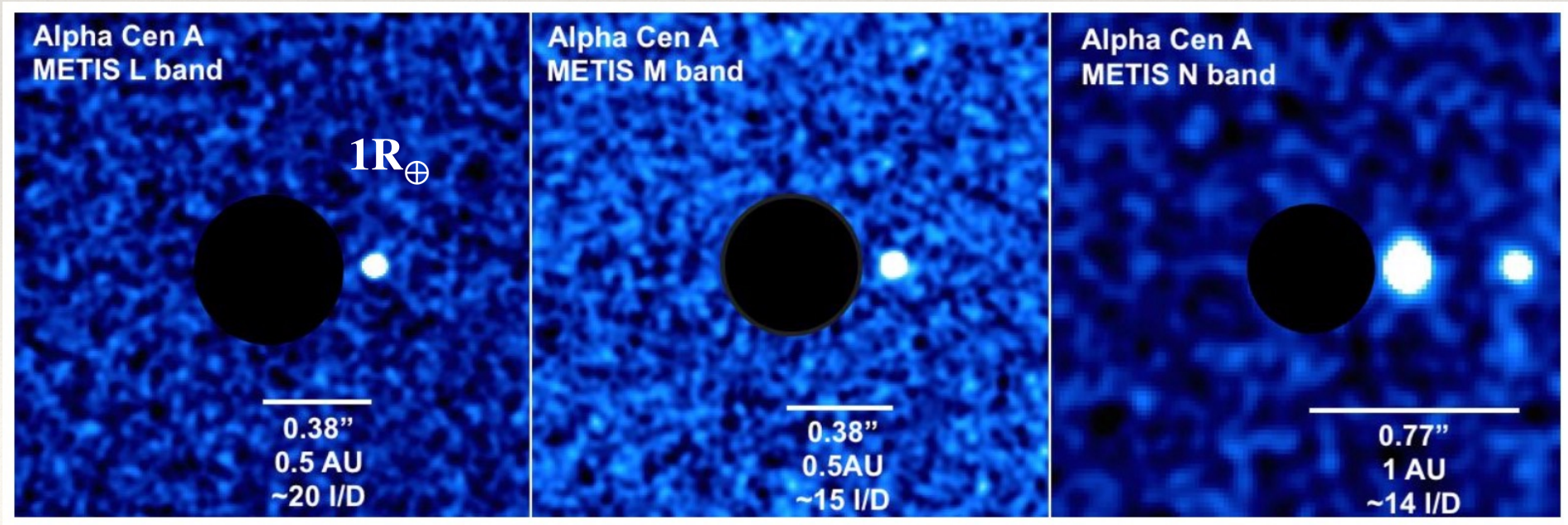
METIS

2 science cases :

- known planets (RV)
- small planets around nearby stars

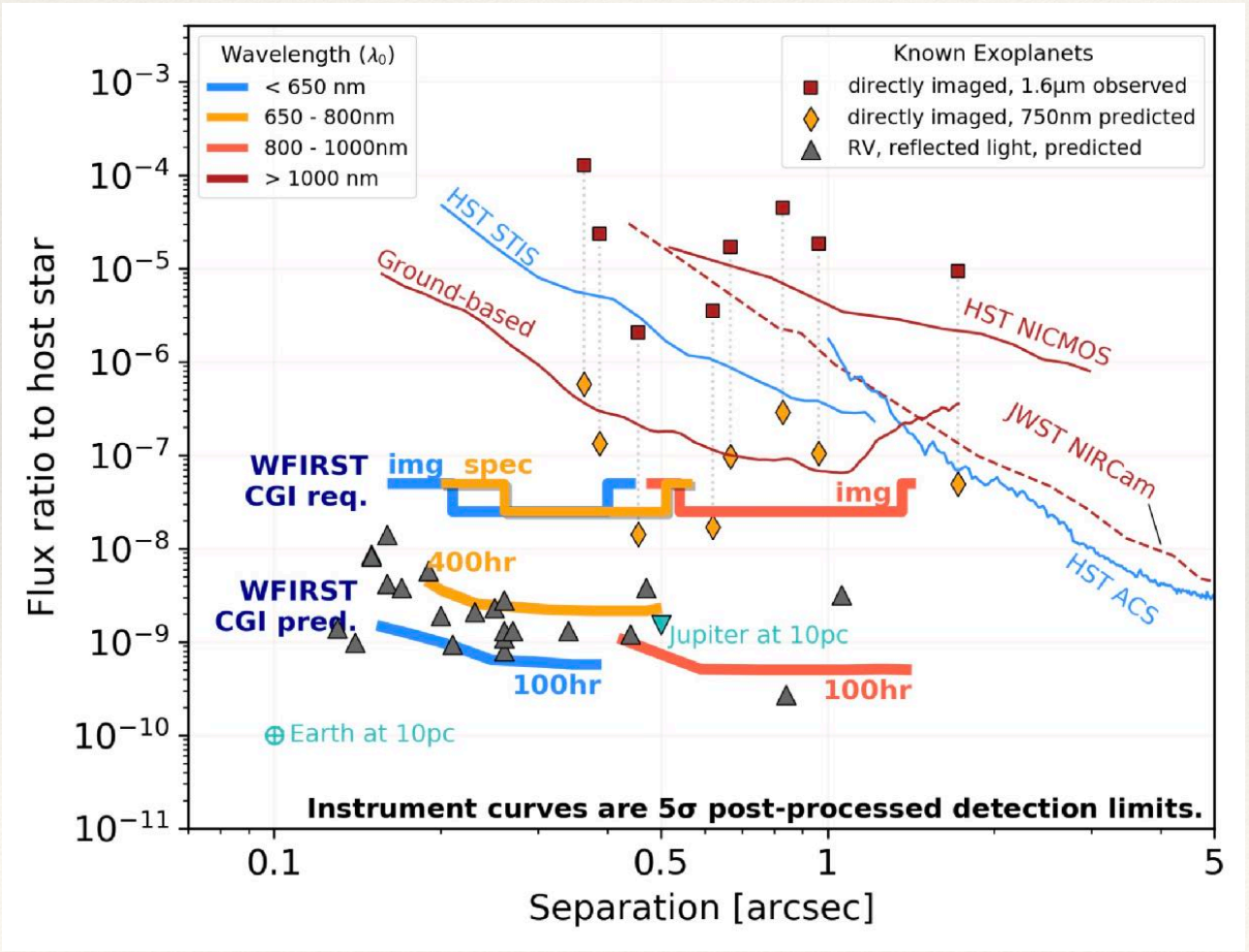


Assuming METIS is background limited …



WFIRST

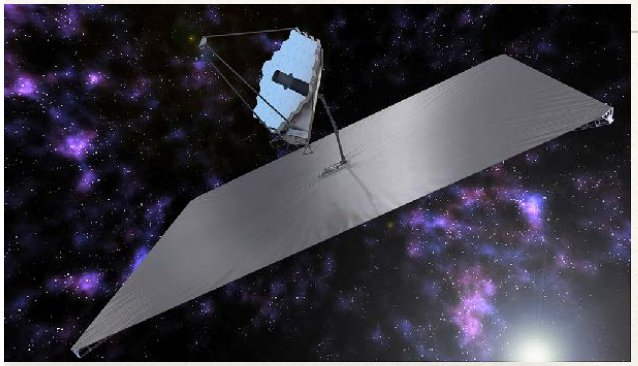
- launch : ~2025
- telescope 2.4m (HST-size)
- 1er objectif: dark energy/matter => WFI
- 2e objectif : exoplanets > WFI (microlensing)
  CGI (imaging)



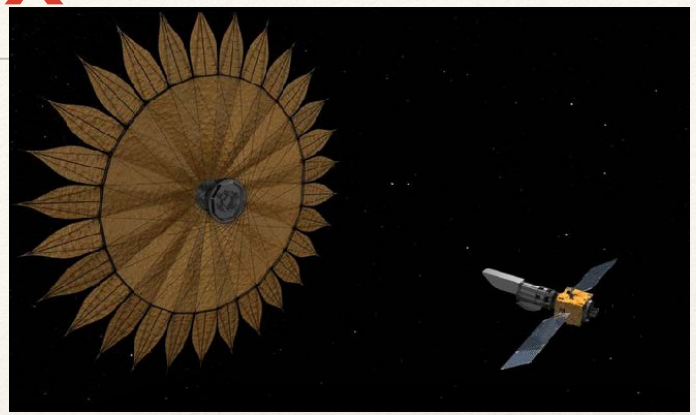
CGI is a technological demonstrator !

imaging : ~12 planets
spectro : ~2 planets

LUVOIR / HABEx

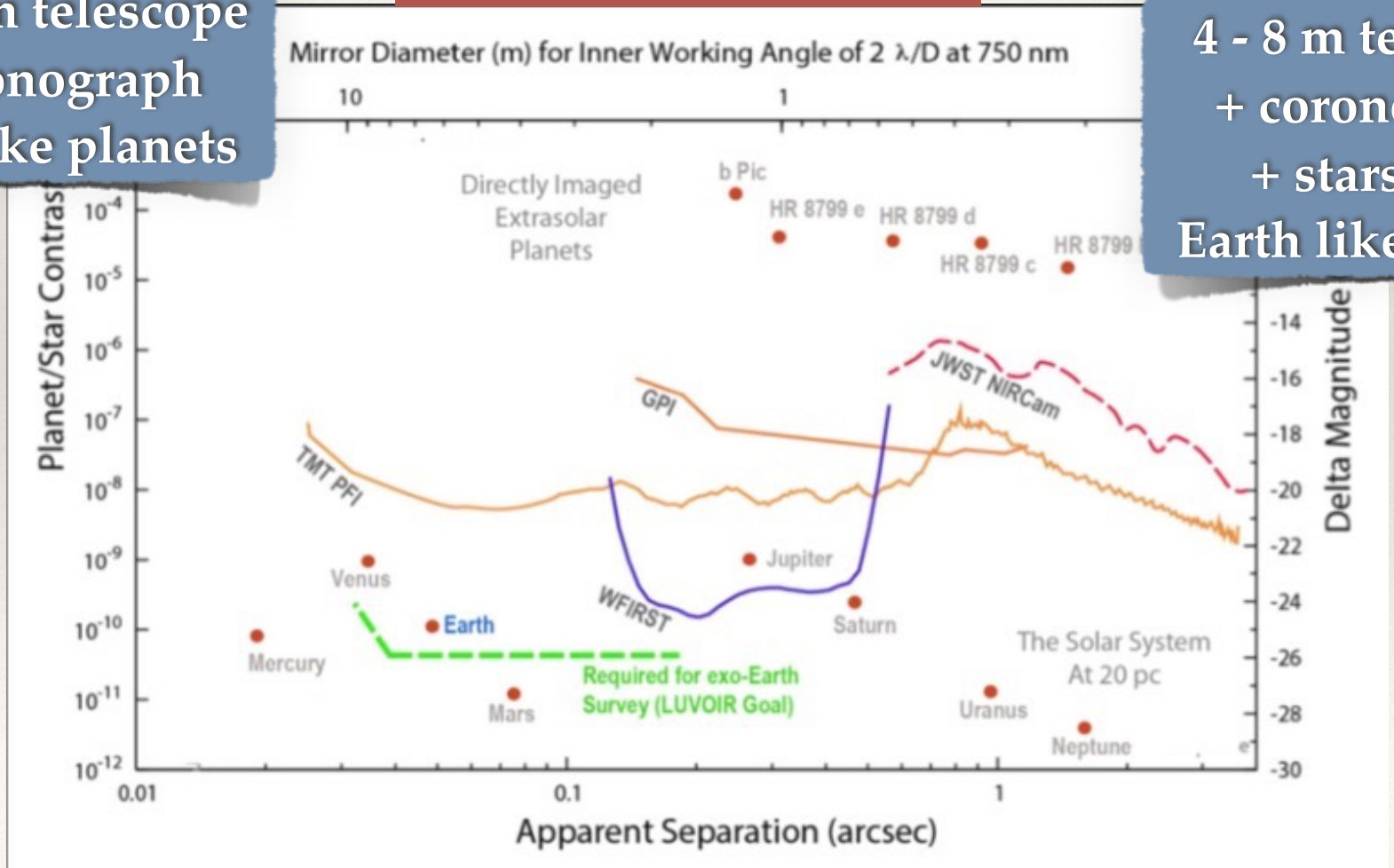


EU Participation
Voyage 2050
Snellen et al.
2019



10 - 12 m telescope
+ coronograph
Earth like planets

4 - 8 m telescope
+ coronograph
+ starshade
Earth like planets



Conclusions

- **currently** : small overlap between transit and imaging
- **WFIRST** : first mature planets in Imaging (spectroscopy?)
- **ARIEL / Imaging**
  - learn about atmosphere of giants at various stages of evolution
  - **Consider** young edge-on systems for ARIEL
- **stronger** synergy requires dedicated instruments for telluric planets (LUVOIR, HABEx)
    - PLATO provides targets (how many? which characteristics?)
    - LUVOIR/Habex observe reflected light. Radius/mass: crucial inputs to leave degeneracies in atmosphere parameters.