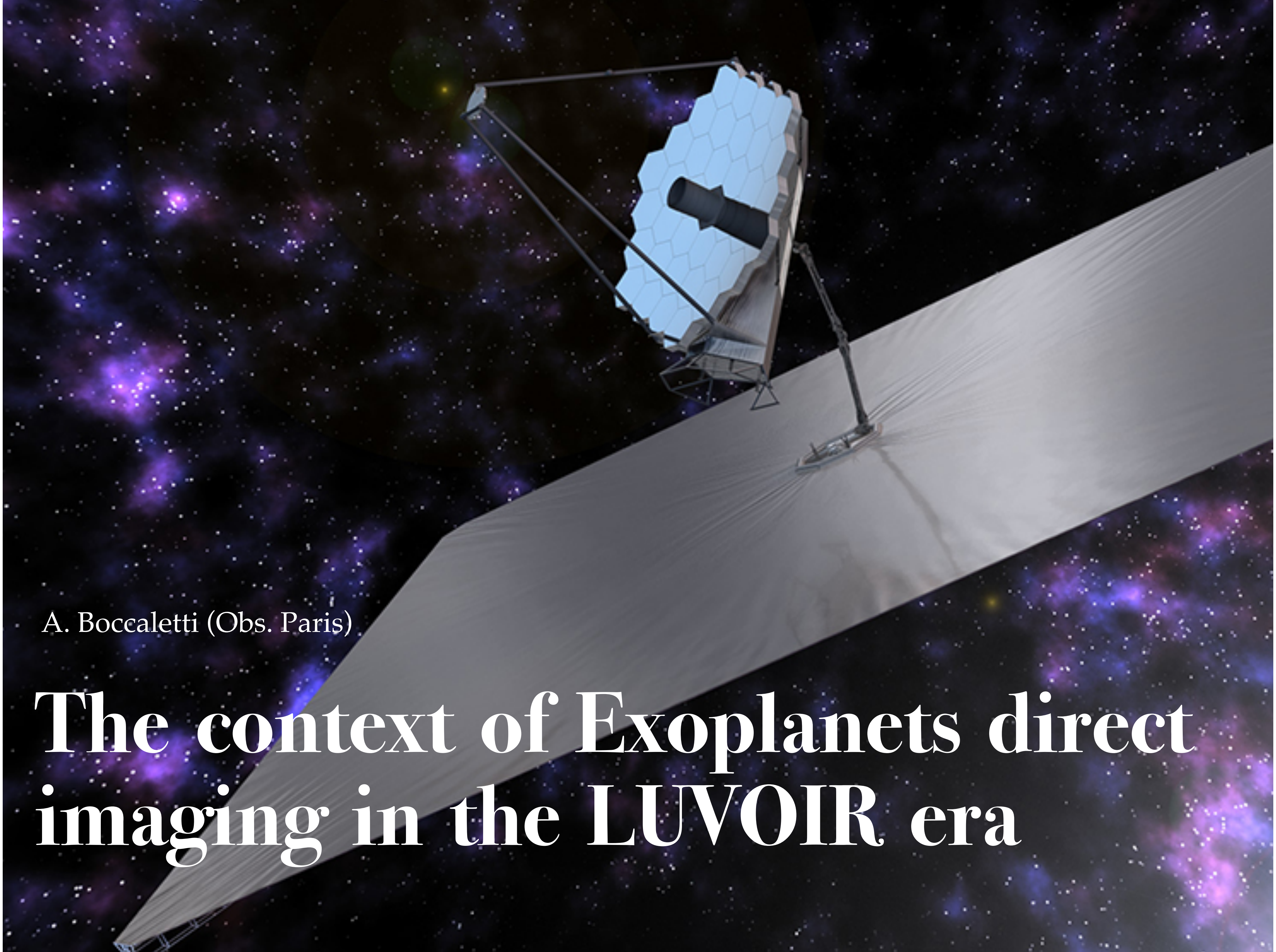
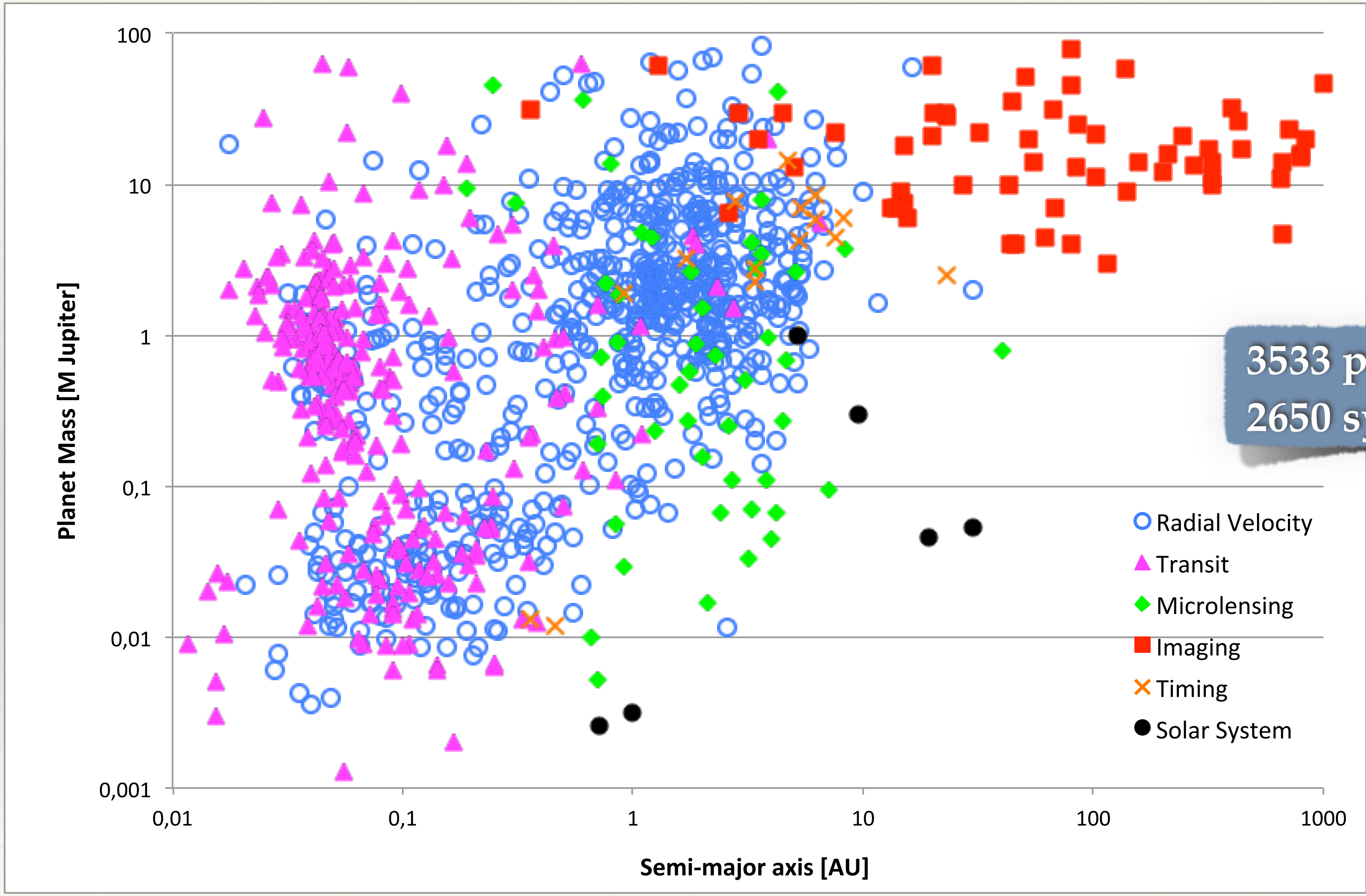


A. Boccaletti (Obs. Paris)

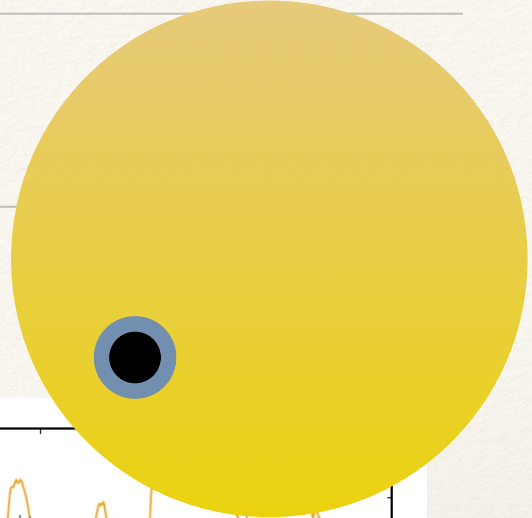
The context of Exoplanets direct imaging in the LUVOIR era

Diagramme masse / séparation

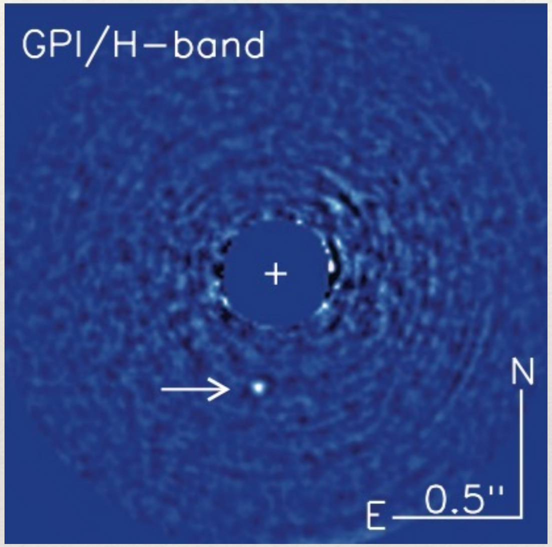


3533 planets
2650 systems

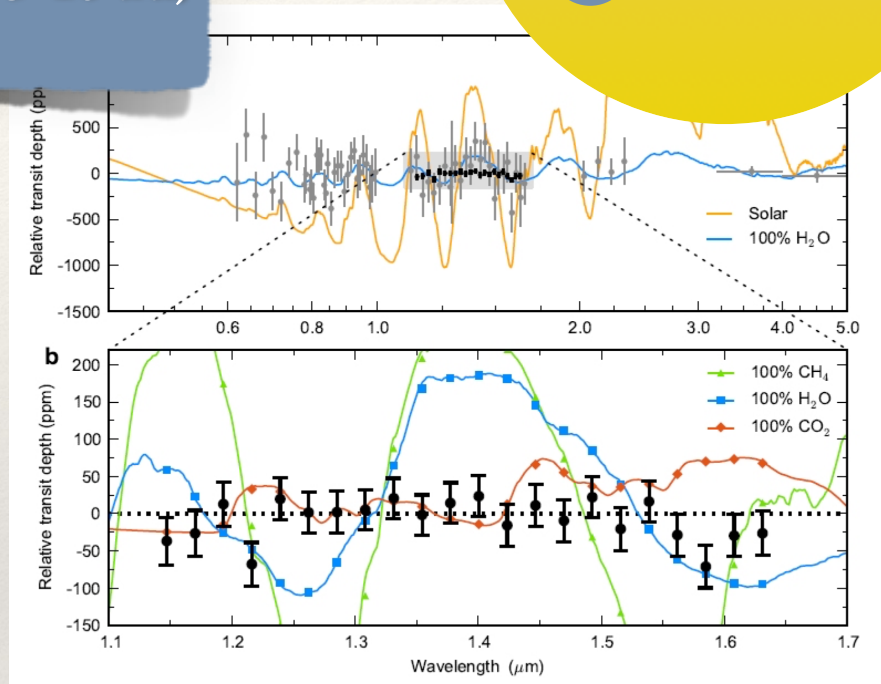
Characterization of Atmosphere



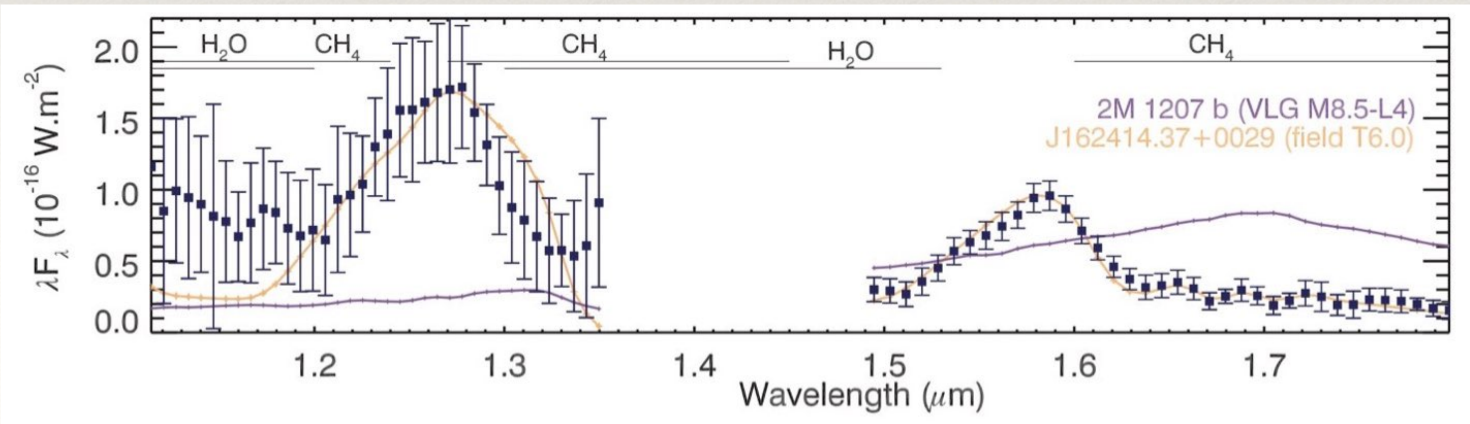
2 ways for characterization
=> 2 classes of planets
direct imaging : long periods (>5-10 au)
transit : short periods (<0.1au)



Macintosh et al. 2015

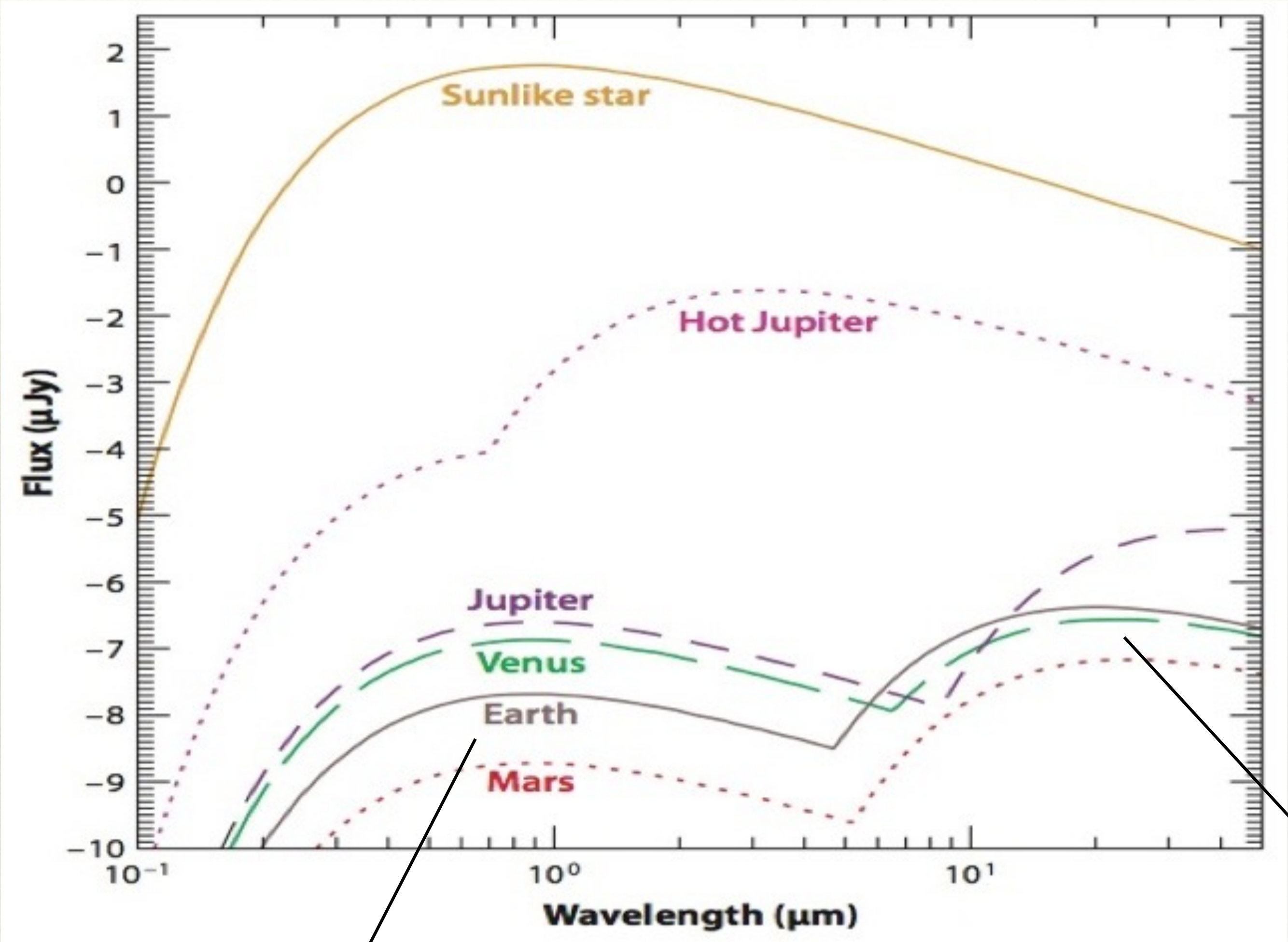


Kreidberg et al. 2013



Contrast

Seager et al. 2010

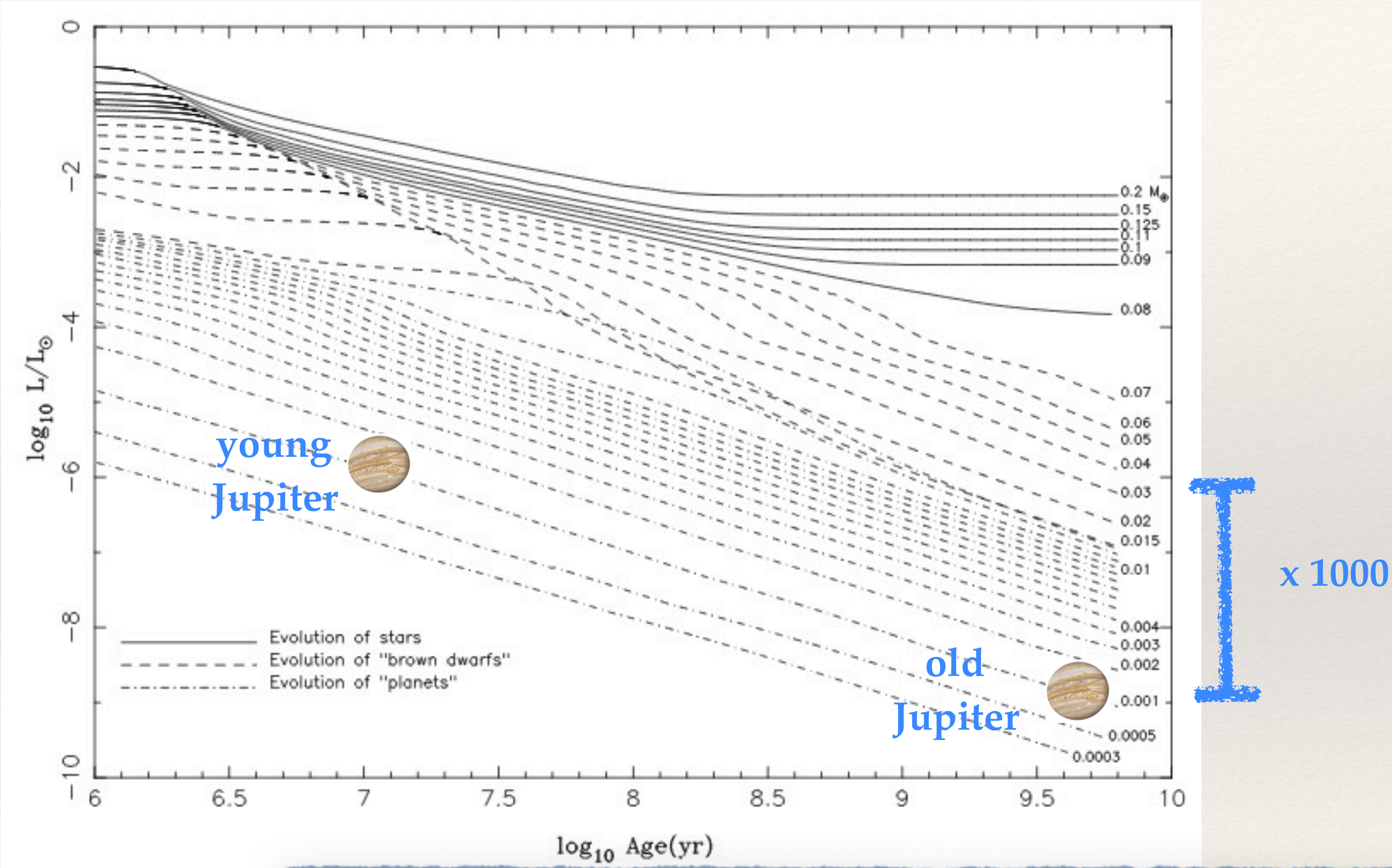


Thermal emission
self luminous planets

Reflected light
irradiated planets

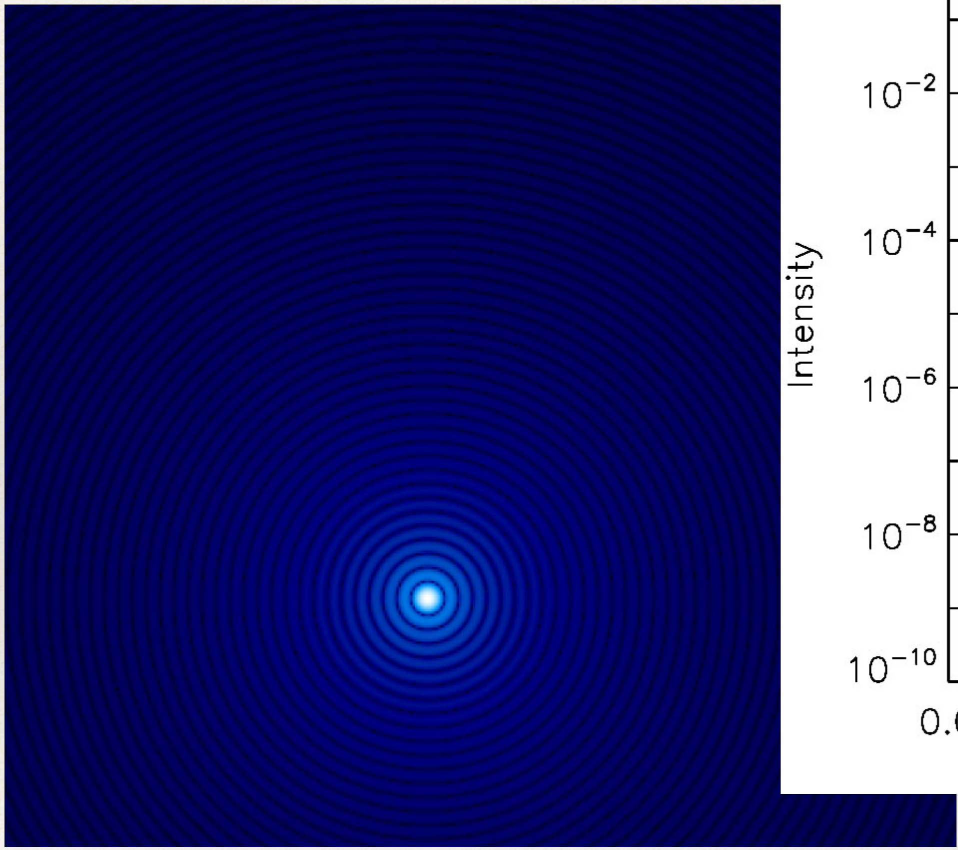
Age - Luminosity

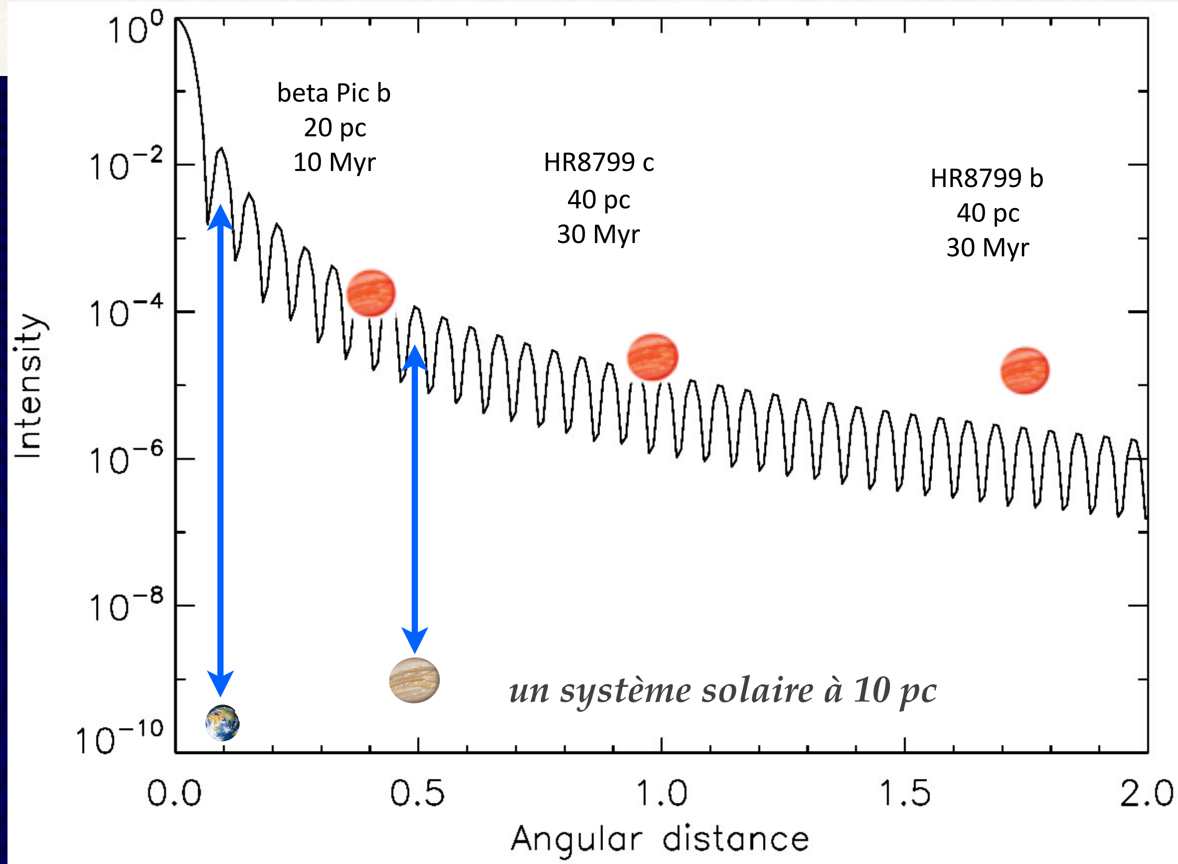
Burrows et al. 1997



Brighter at young ages …
… but more difficult to determine young ages

Diffraction

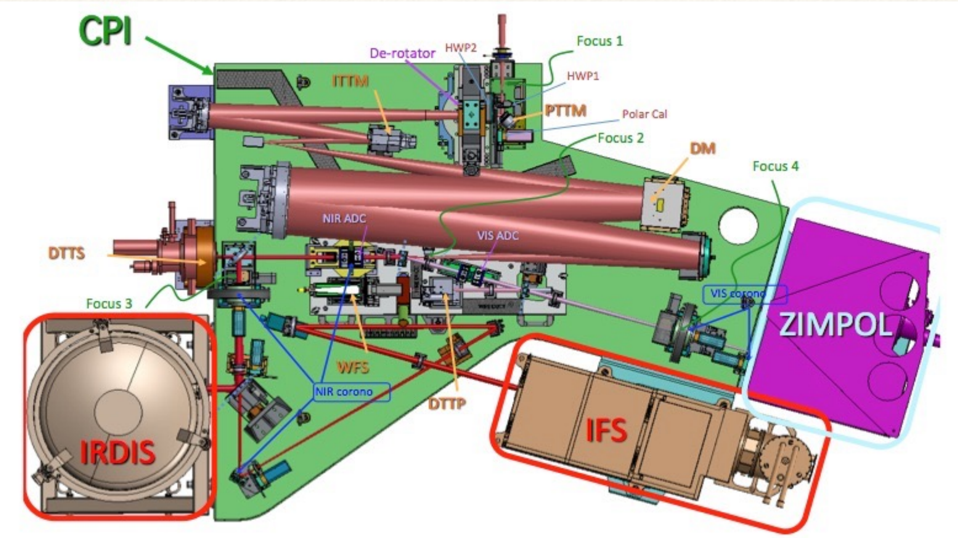


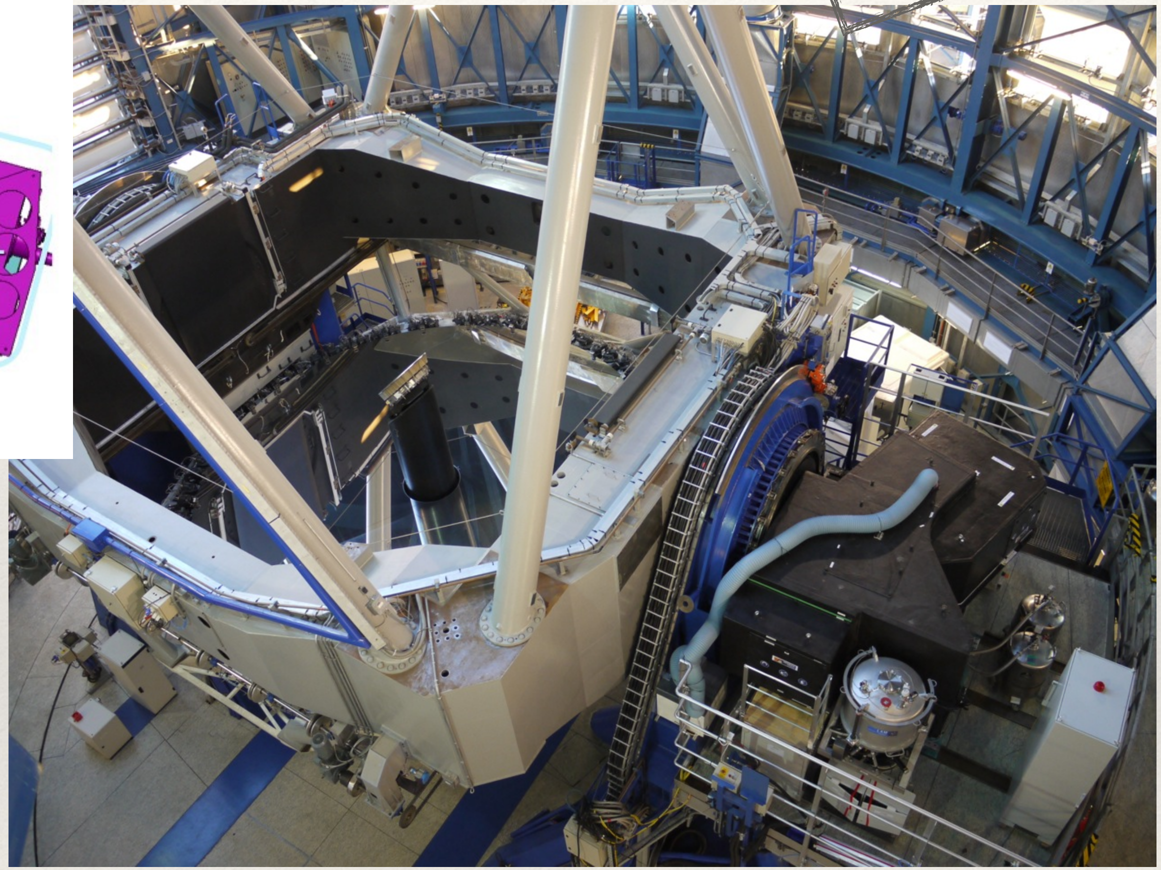


PRESENT

GPI / SPHERE / SCEXAO / MagAO ..

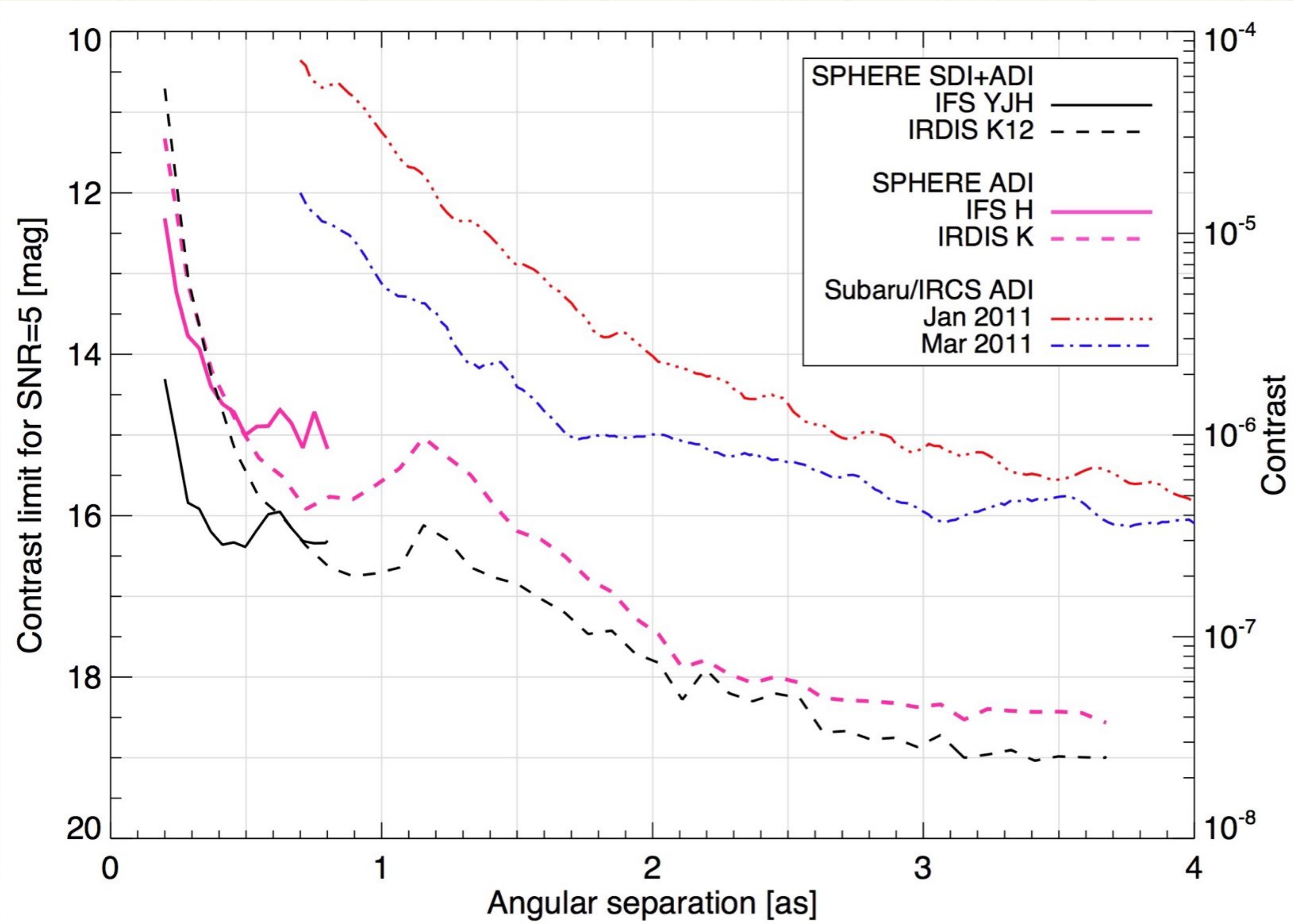
near IR





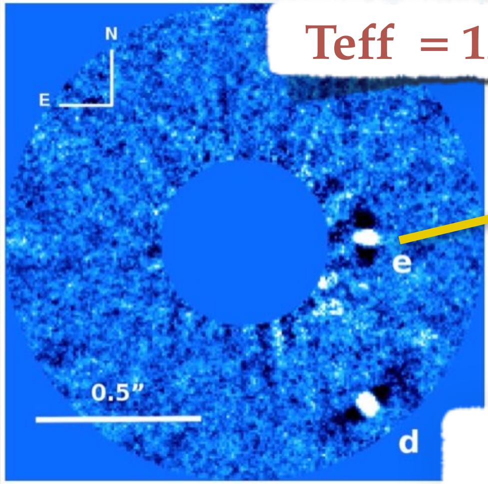
- **extreme AO** (SAXO)
- achromatic **coronographs** (>0.1")
- **differential imaging**
- spectral / angular / polarimetric
- **3 instruments** :
  - camera **IRDIS** : 0.95 - 2.3mic, 11"x12"
  - integral field spectrograph **IFS** : 0.95 - 1.85 mic, 1.77"x1.77"
  - polarimeter **ZIMPOL** : 0.6 - 0.9mic, 3.5"x3.5"

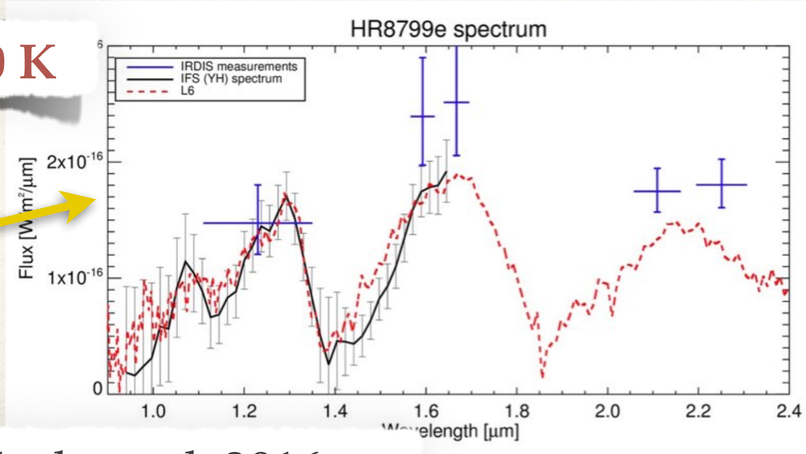
SPHERE best contrast (ever)



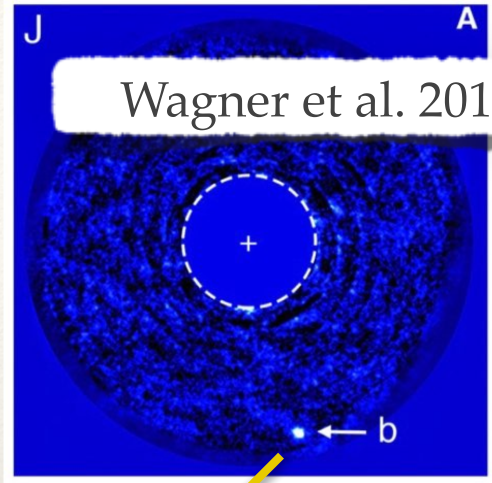
Exoplanets with SPHERE

Teff = 1200 K

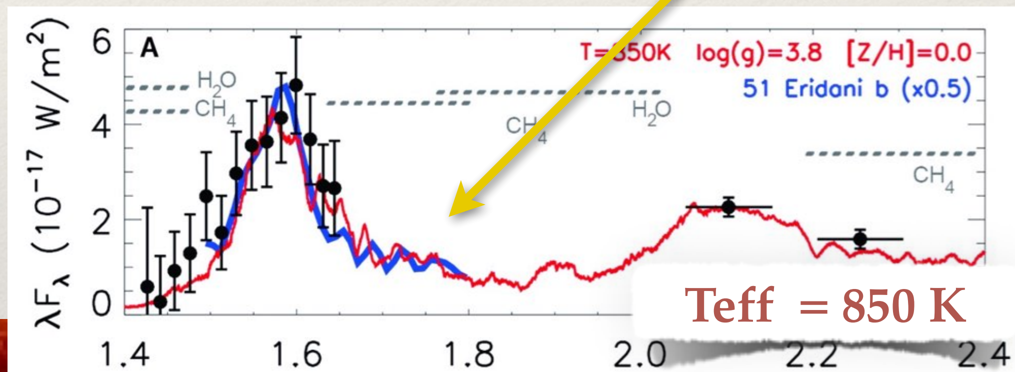




Zurlo et al. 2016,
Bonnefoy et al. 2016

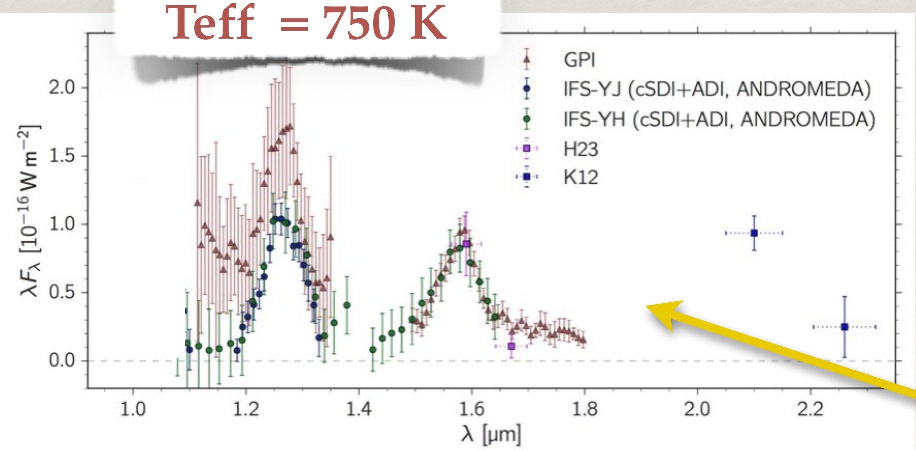


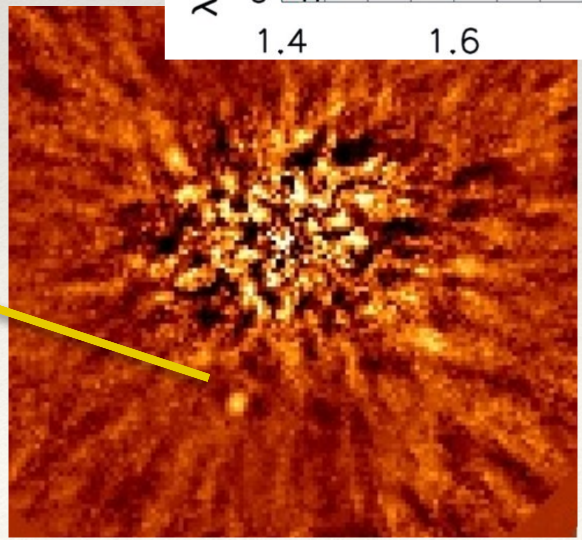
Wagner et al. 2016



Teff = 850 K

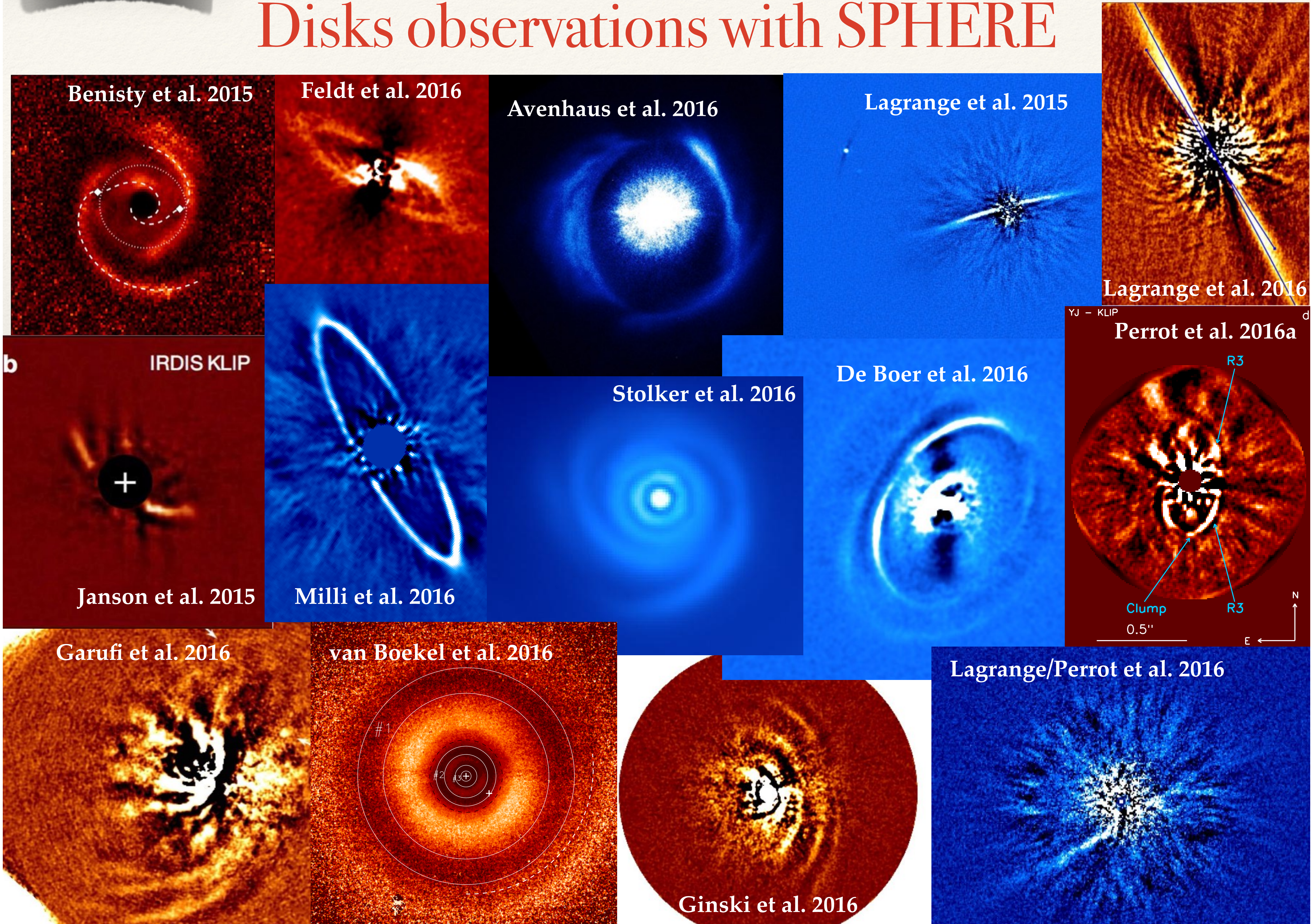
Teff = 750 K





Samland et al. 2016

Disks observations with SPHERE



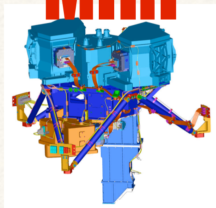
James Webb Space Telescope

near + mid IR

NIRCAM

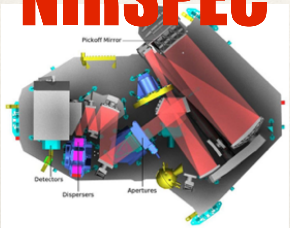
US : 0.6 - 5 µm
coronography + transit

MIRI



Europe/US : 5 - 28 µm
coronography + transit

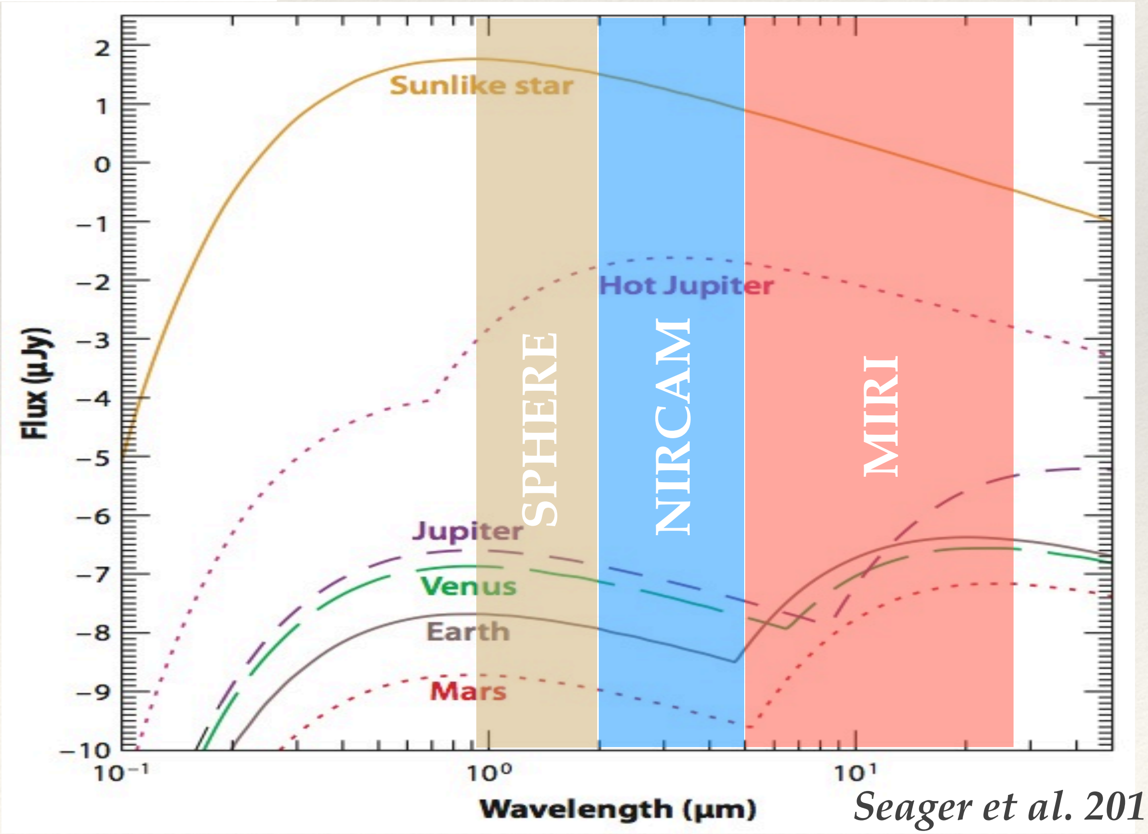
NIRSPEC



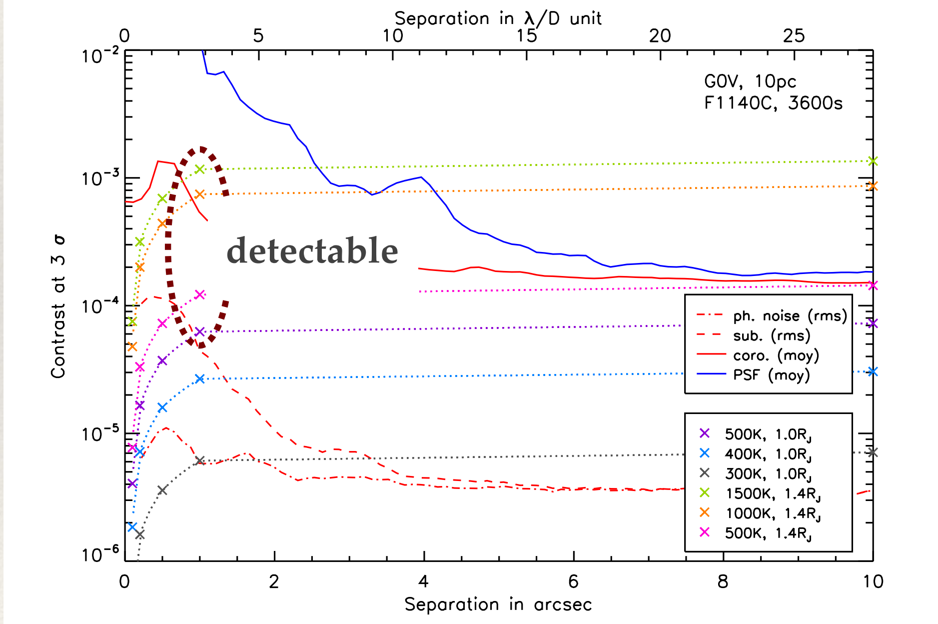
Europe : 0.7 - 5 µm
transit

NIRISS

Canada : 1 - 5 µm
coronography + transit



Seager et al. 2010

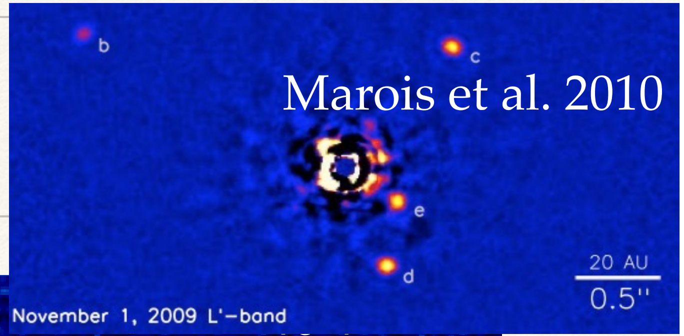


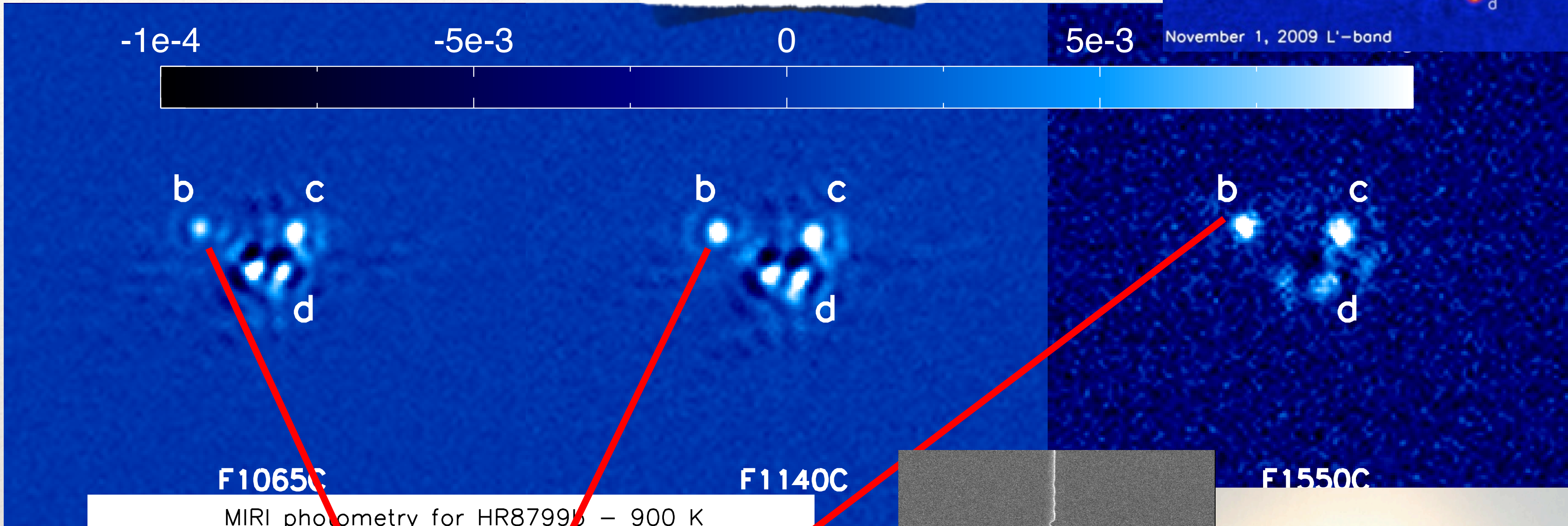
Boccaletti et al. 2015

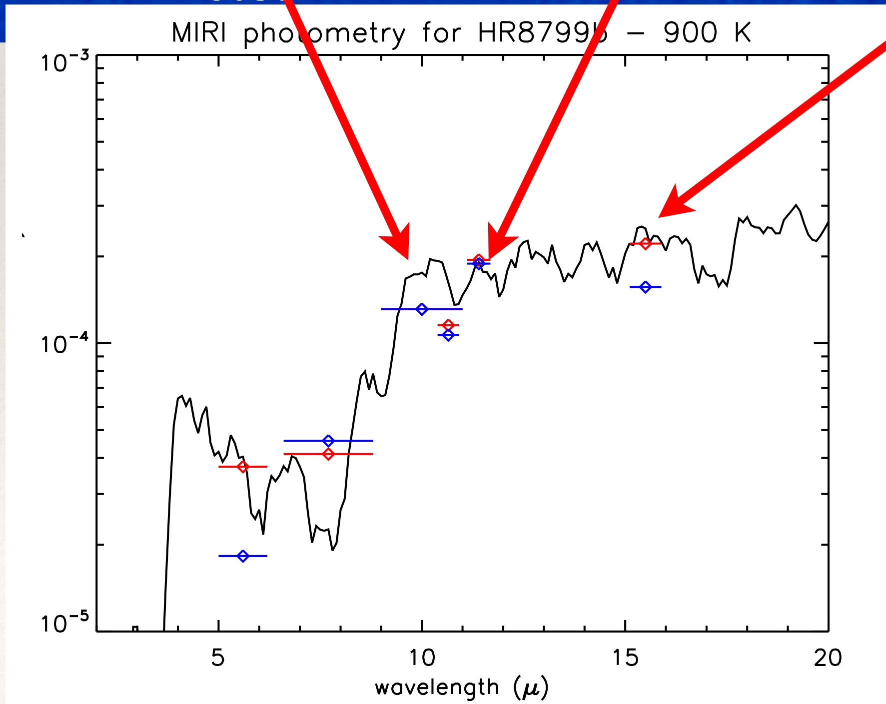
MIRI performance

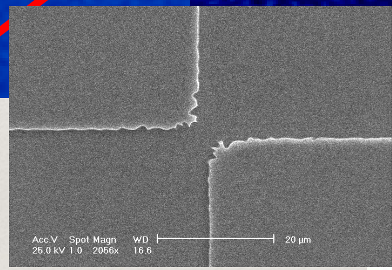
HR8799

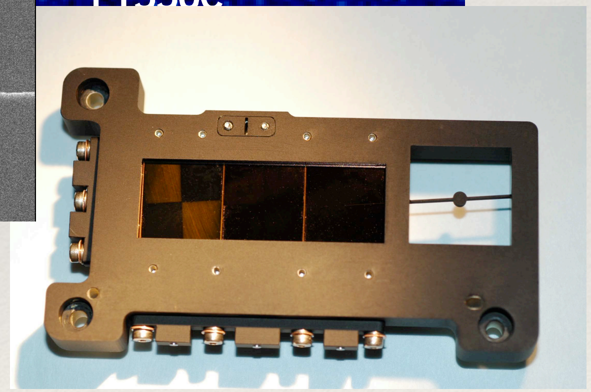
Boccaletti et al. 2015

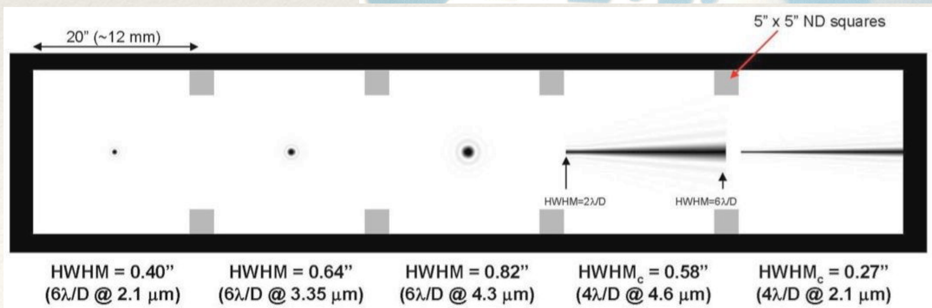






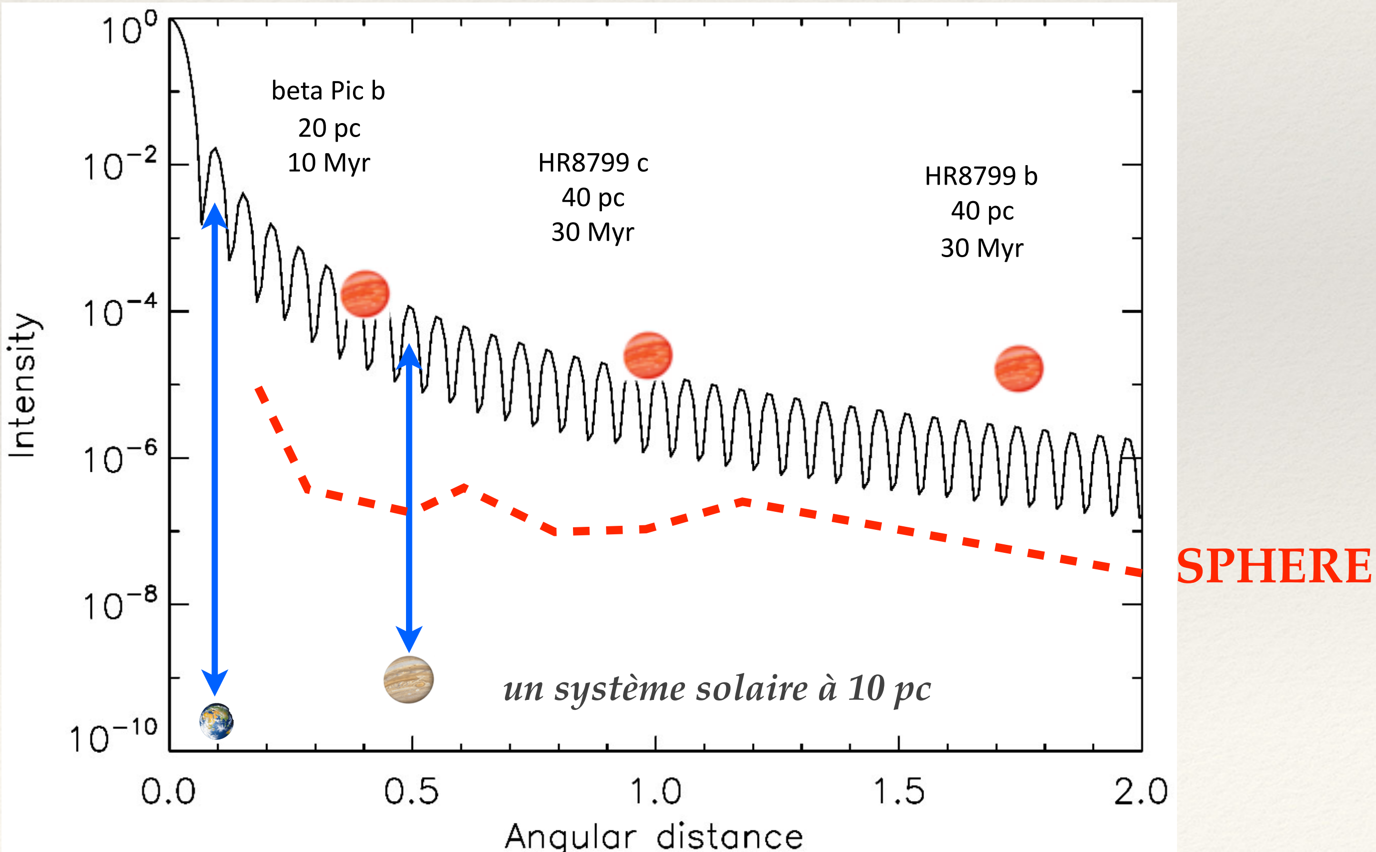






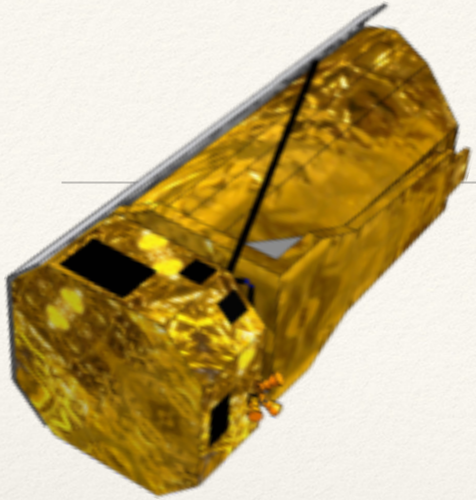
Today's Performances

- best contrast ~ a few 10^6
- detection > 5-10 au for stars <100pc
- a few masses of Jupiter
- near / mid IR photometry & spectroscopy (R<100)
- morphology : orbit characterization / interaction with disks

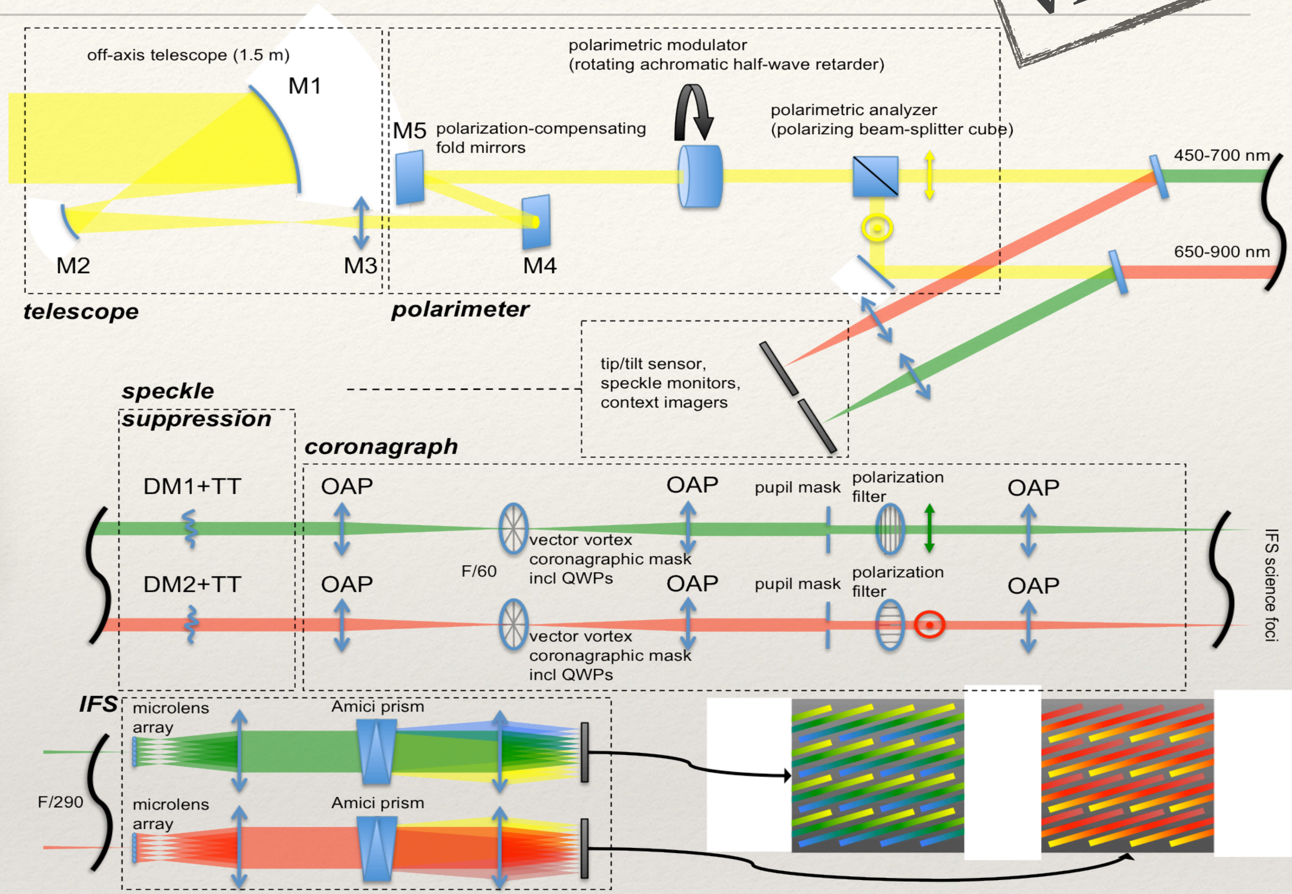


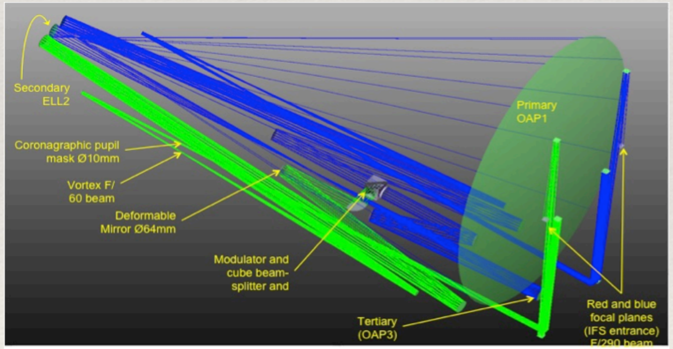
SPICES : concept study

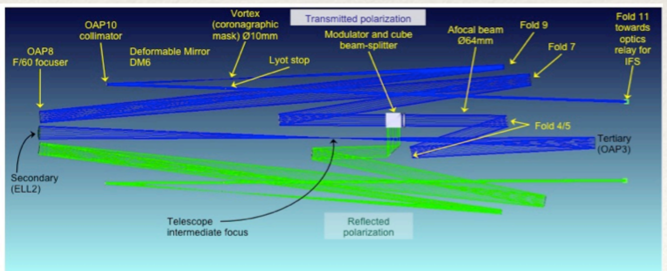
Visible

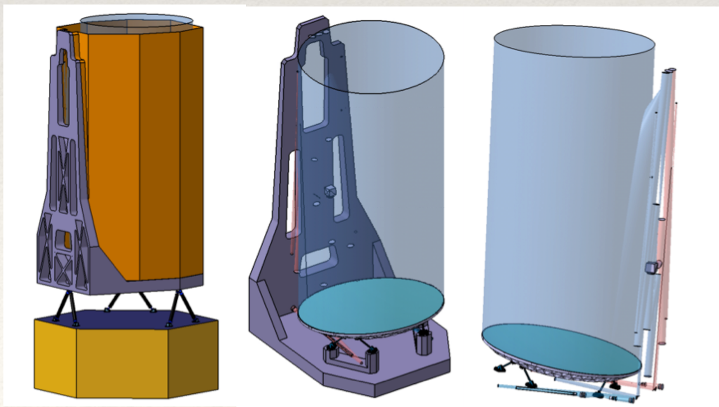


submitted to Cosmic Vision as M3 in 2010 (Boccaletti et al. 2012)





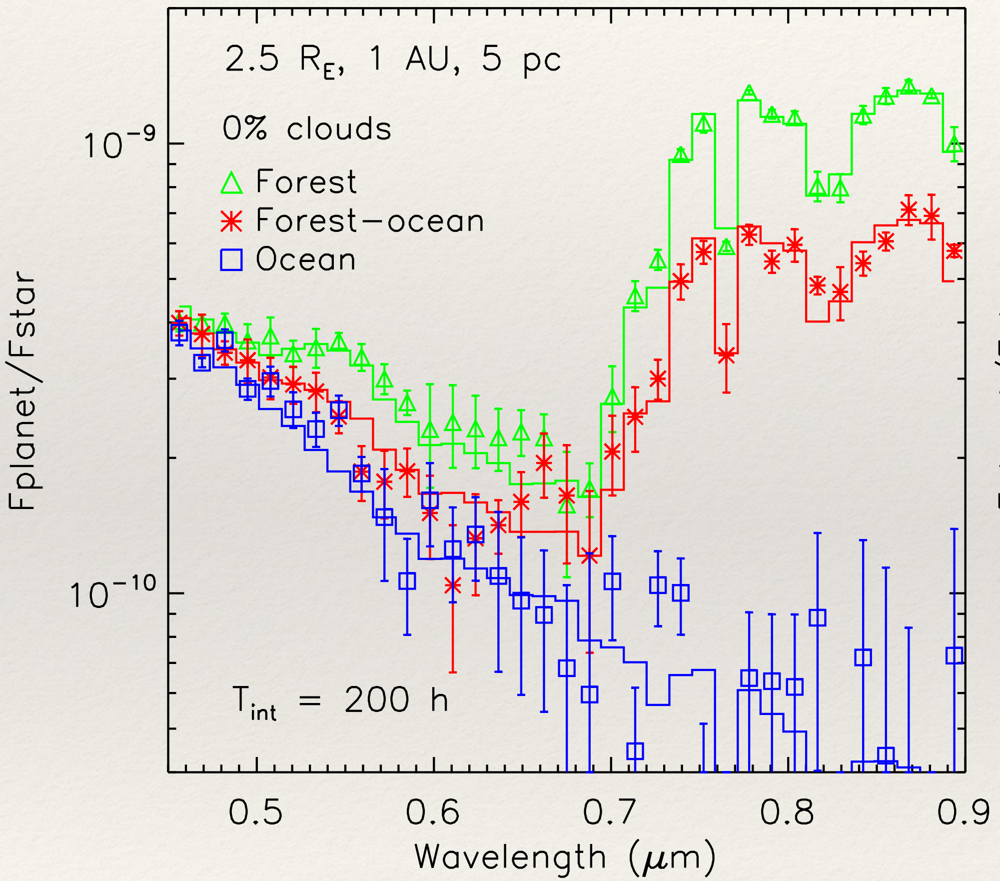




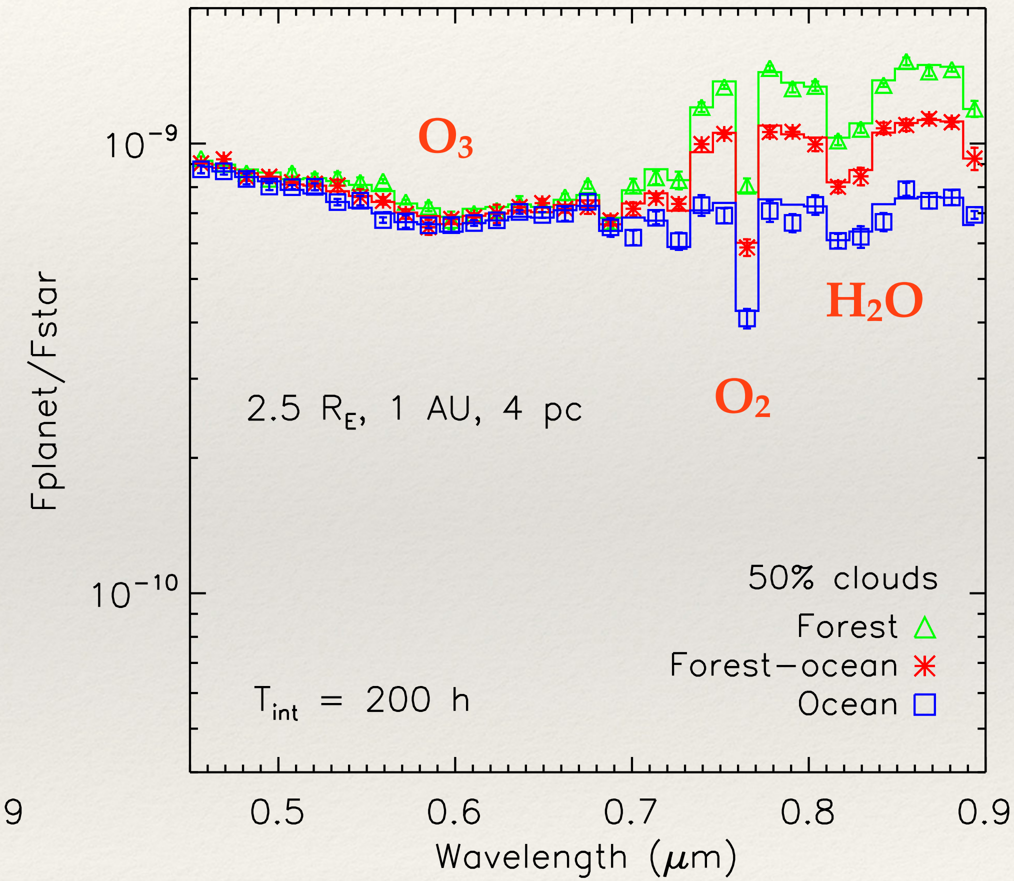
SPICES : tellurics

modelling for G stars (Maire et al. 2012)

No clouds



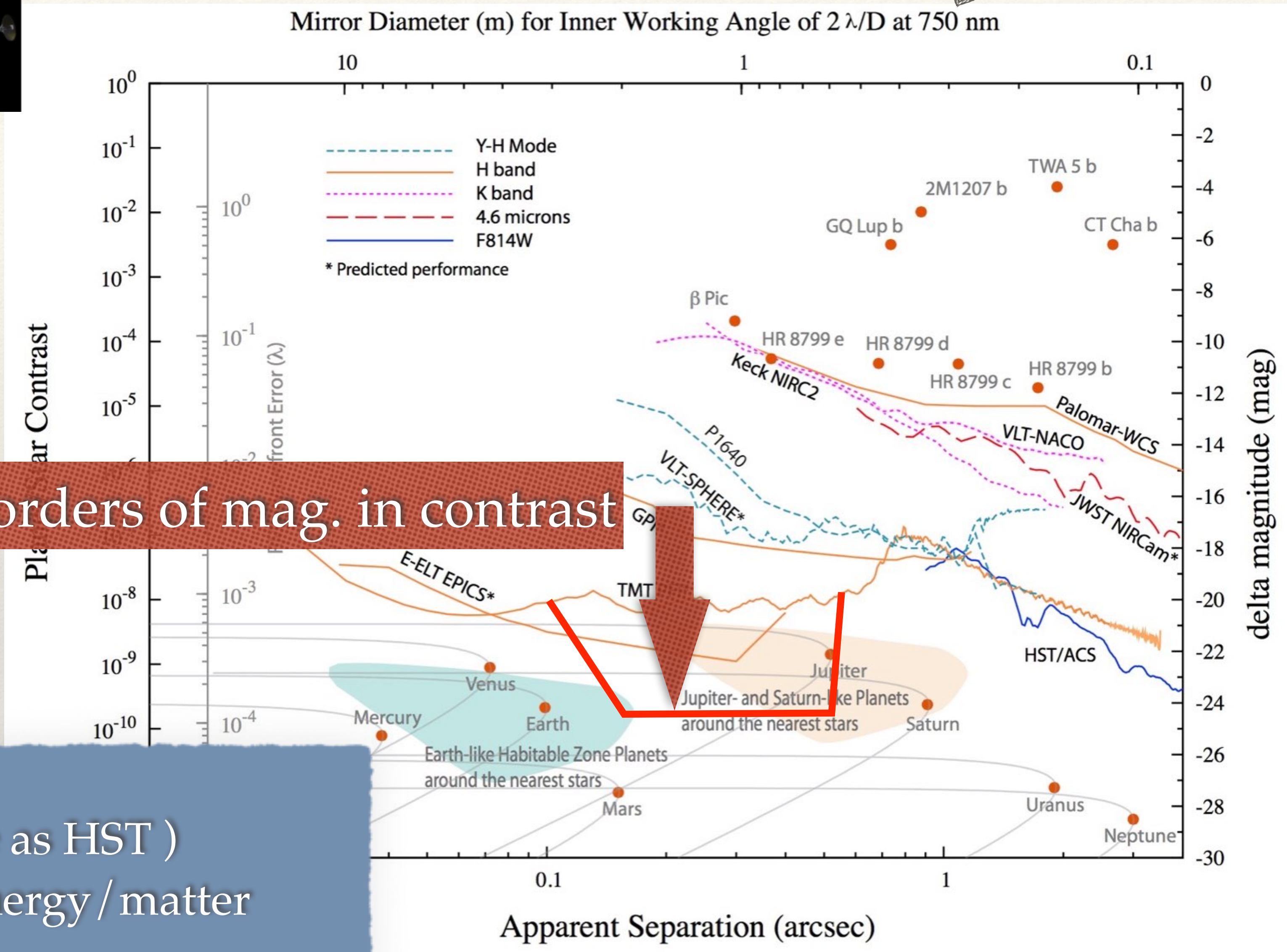
50% Clouds



comparative planetology of tellurics

WFIRST (>2025)

Visible



~3 - 4 orders of mag. in contrast

Mawet et al. 2012

launch : ~2025
2.4m telescope (same as HST)
1er objective: dark energy / matter
=> WFI
2nd objective : exoplanets
=> WFI (microlensing) / CGI (imaging)

WFIRST (>2025)

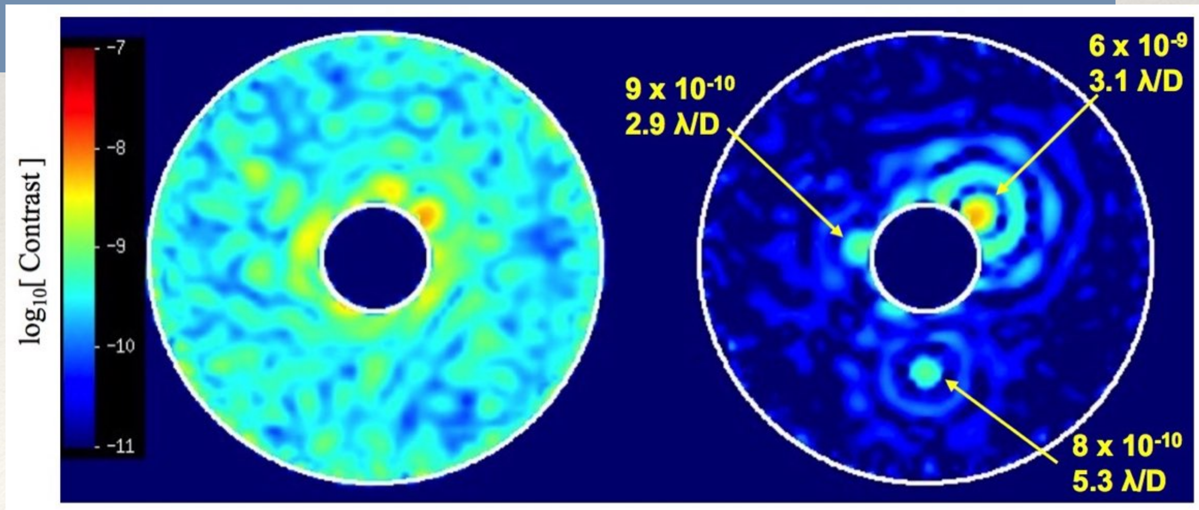
WFIRST coronagraph (CGI) considered as a **DEMONSTRATOR**

Telescope pupil is **NOT** optimal for coronagraphy (large obscuration, spiders …)
=> requires pupil mapping with DMs => low throughput (3-4%)

Spectroscopy doable (R=70, 600-970 nm):
3 bands : 660, 770, 890 nm, 18% bandwidth

targets: mostly RV giants (mature) + Gaia ?

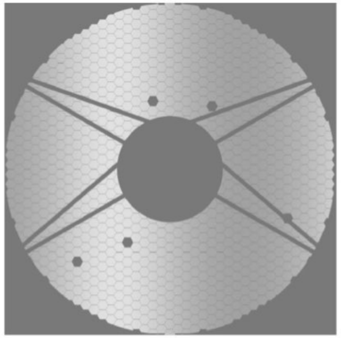
EUROPEAN INTERESTS ???

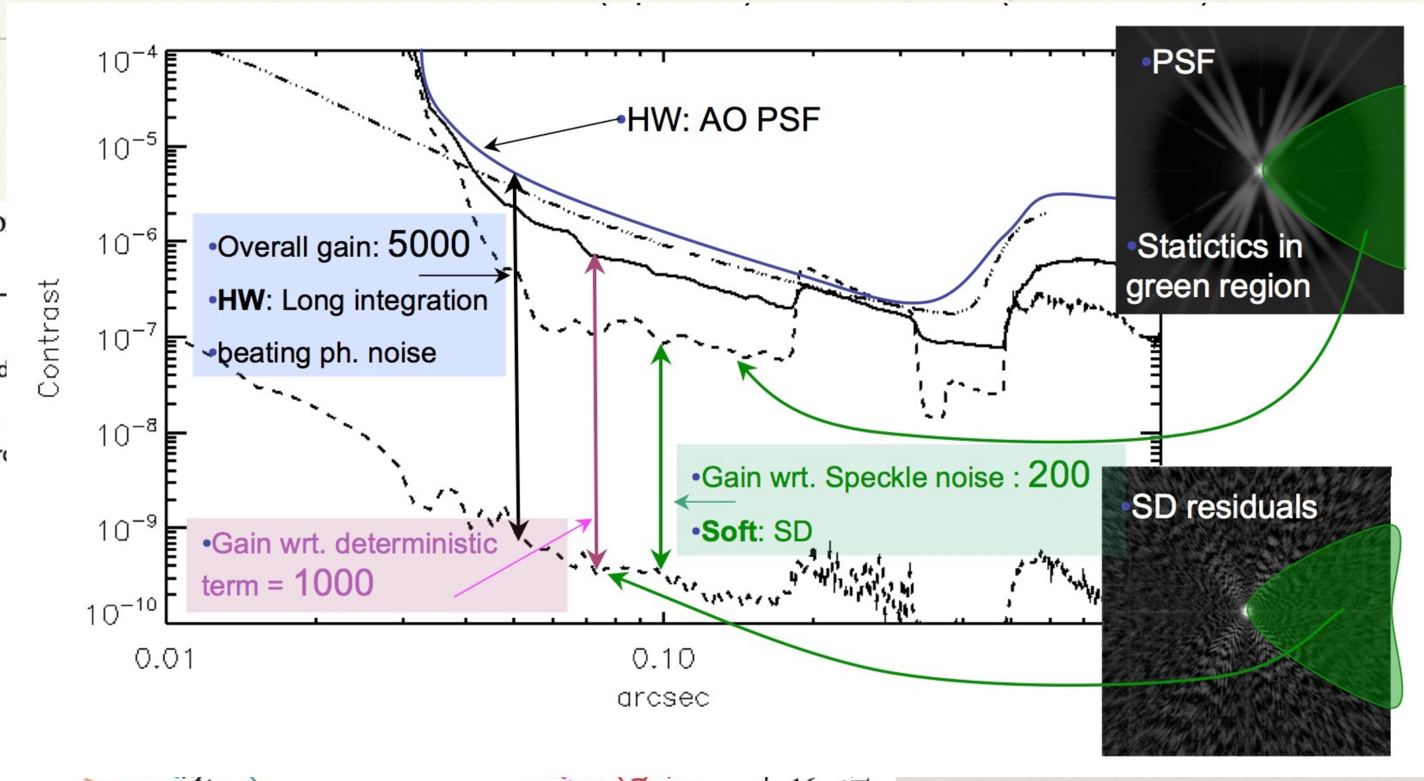


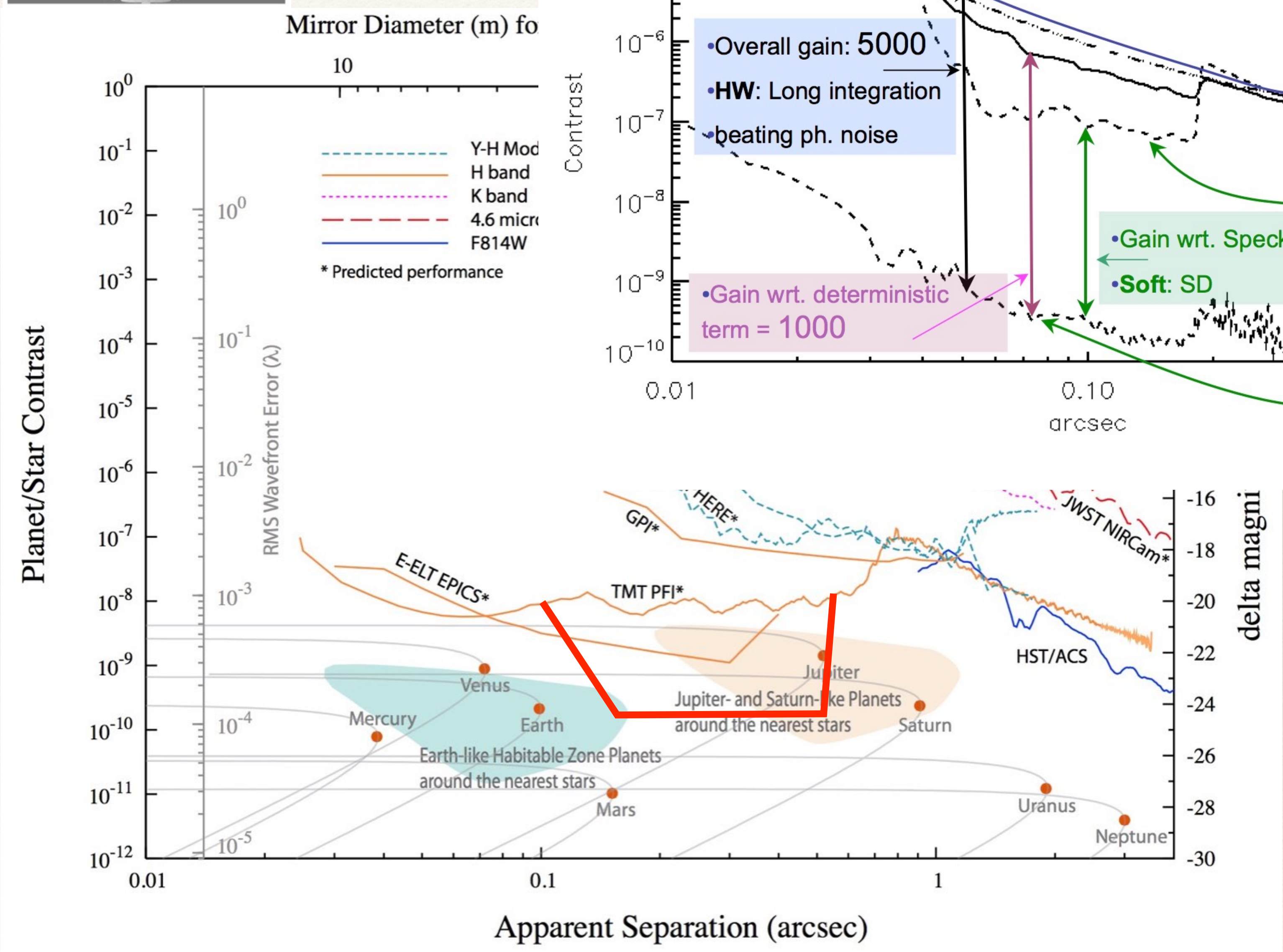
47 UMa simulations (SDT report)
using beta UMa as a reference

ELT - PCS (>2030)

near IR

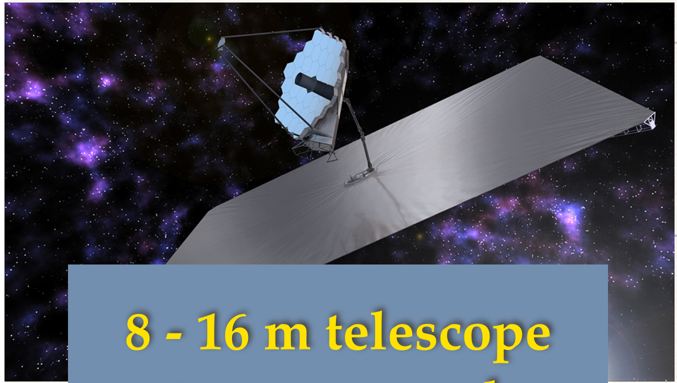




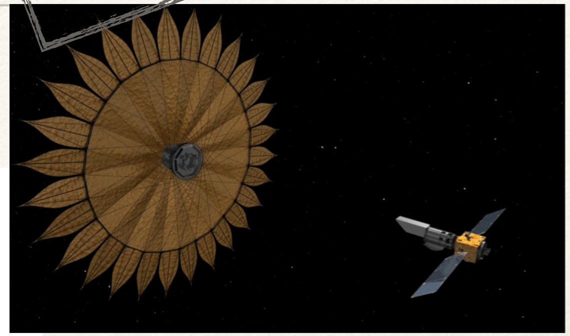


LUVOIR / HABEX

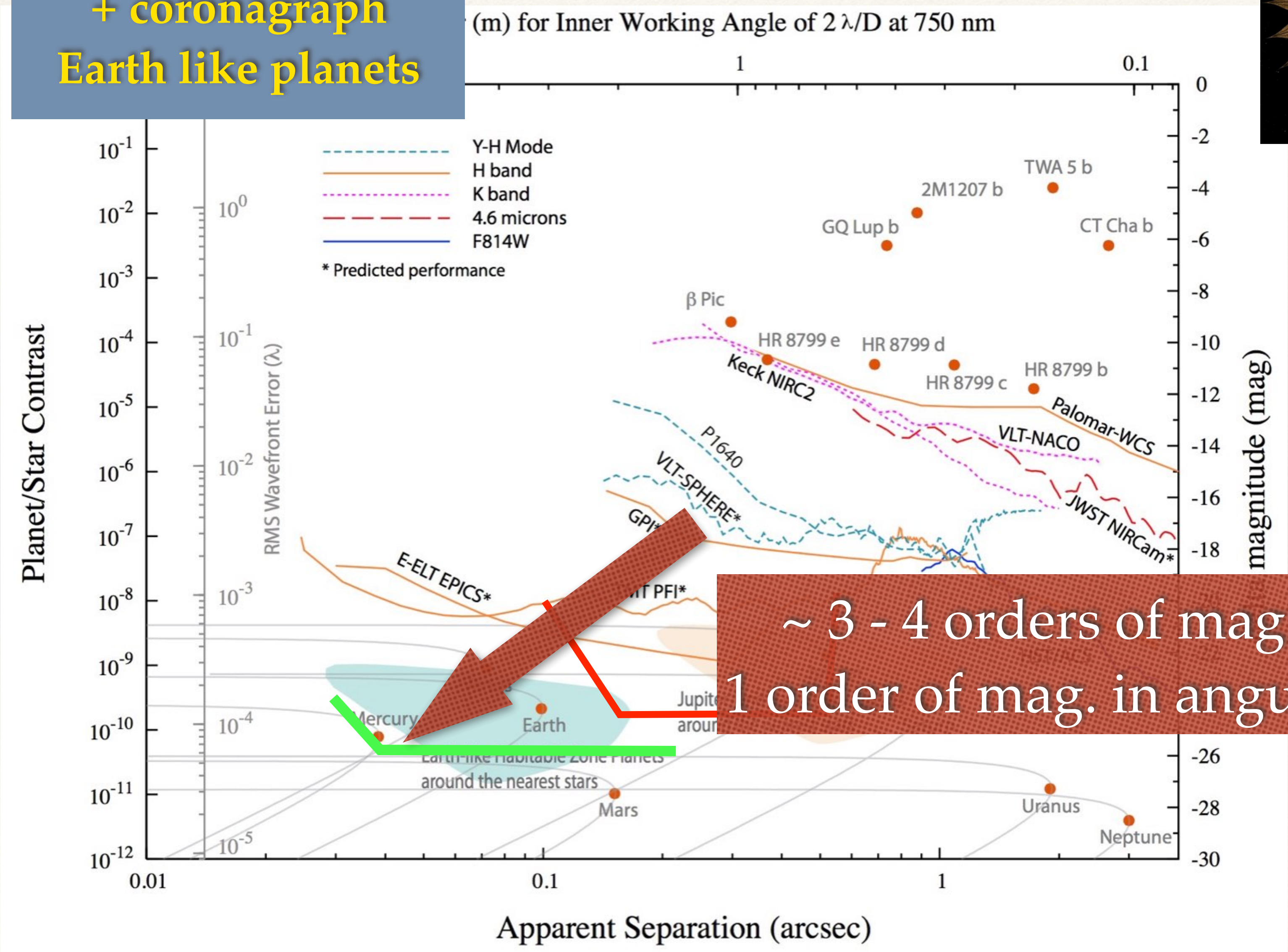
UV to near IR



8 - 16 m telescope
+ coronagraph
Earth like planets



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



~ 3 - 4 orders of mag. in contrast
1 order of mag. in angular resolution

Conclusions

LUVOIR science (and instrument perf.) is a huge GAP vs. previous projects/missions …
BUT :

- worth to go as we will definitely need large telescopes in space
- Earth like / biosignatures should be the goal for future large scale missions
- several problematics to be solved :
    - **FIND THE PLANETS !!! survey from LUVOIR or previous missions ?**
    - **EXTEND high contrast capabilities in the UV: 0.2mic is challenging, WFE issue**
    - **high contrast in the 10^{10} range requires optimized instruments**
    - **coronagraphy with segmented telescope : doable but with costs (throughput …)**
    - **jitter impact, achromatic devices (UV to near IR), DM in series**
    - **extend science cases : other planets in ref. light & DISKS**