SPHERE
Spectro-Polarimetric
High-contrast
Exoplanet REsearch

Planets and brown dwarfs with SPHERE

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+

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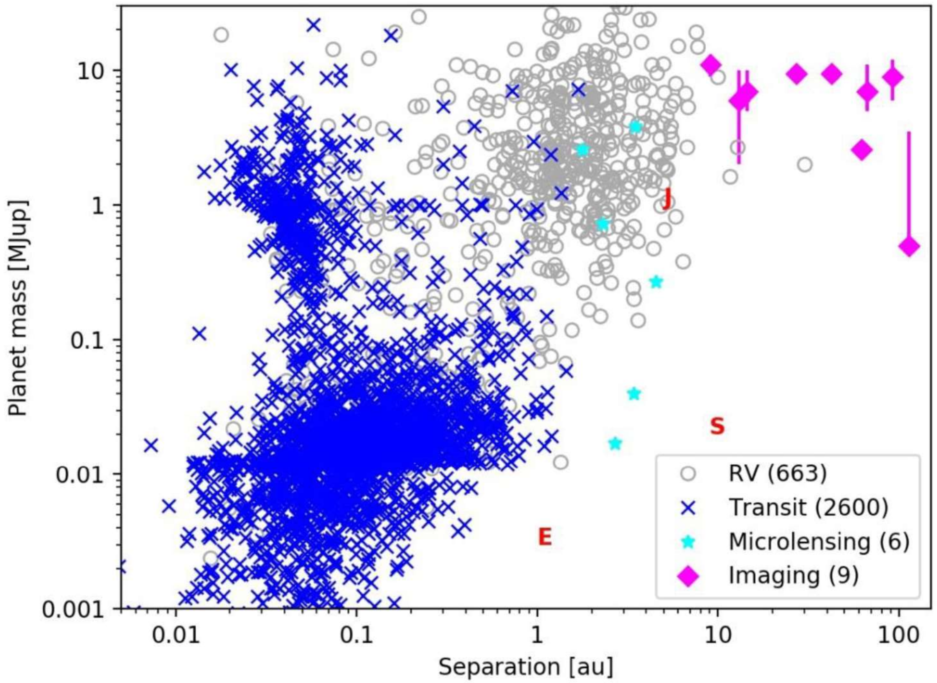
The field of extrasolar planets today

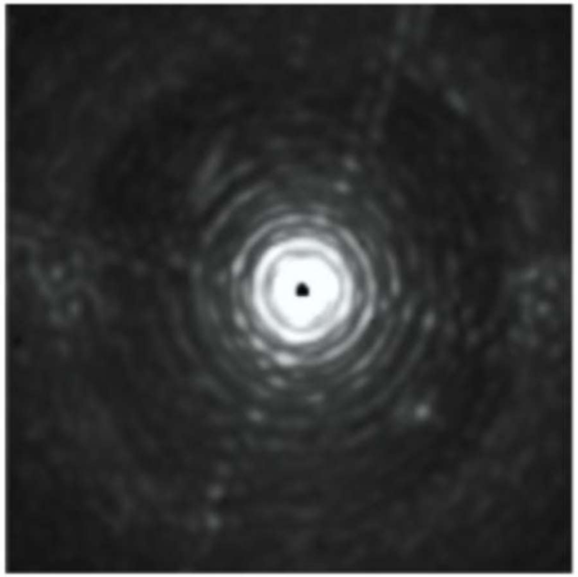


- Thousands of exoplanet detected
- Just a few tens with direct imaging
- Challenging technique due to small angular separation and high luminosity contrast

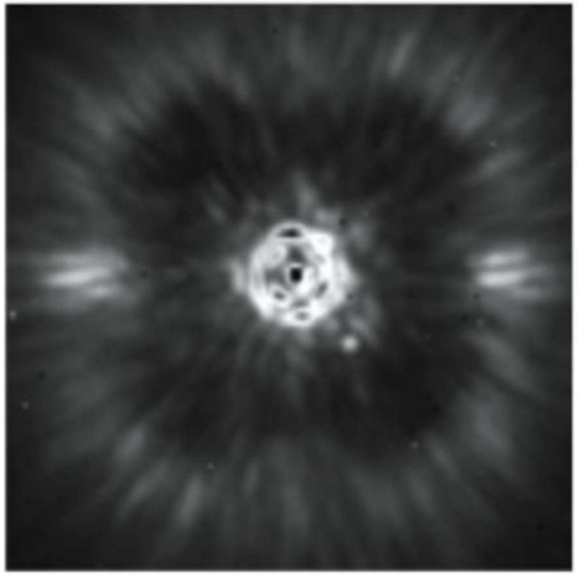
Why direct imaging?

1. Allows to determine the substellar object orbit.
2. Spectro-photometry of the companion.
3. Probe the interaction substellar object – disk.
4. Precise characterization of the objects (in conjunction with indirect techniques).
5. High contrast spectroscopy (informations about presence of clouds and gravity.

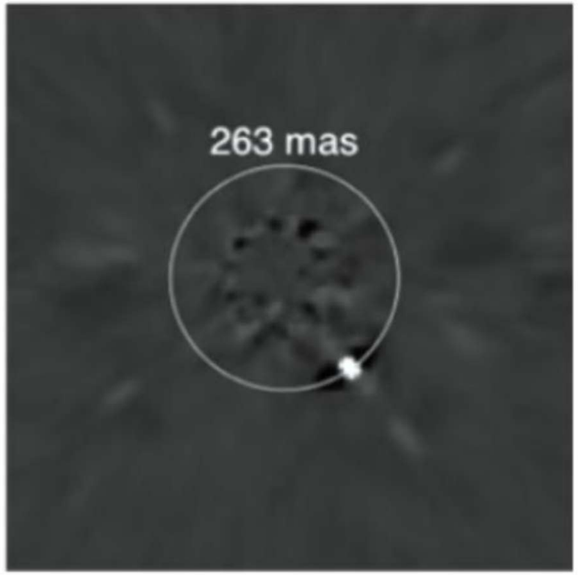
High contrast imaging pillars



High order AO: Contrast ~ 10^{-3}

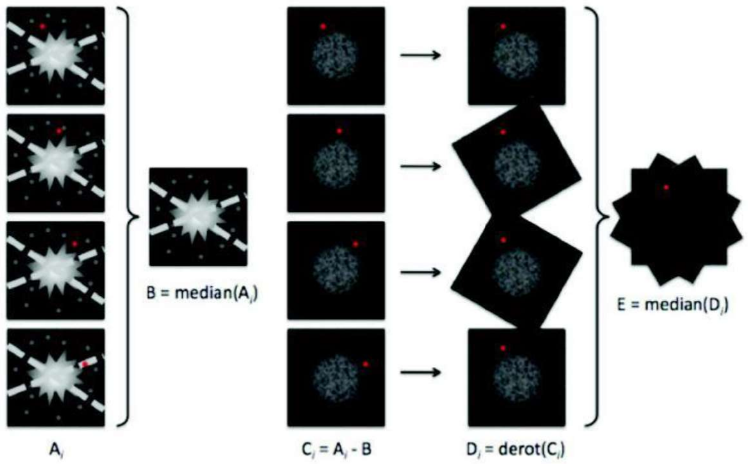


High efficiency coronagraphy: Contrast ~ 10^{-4}

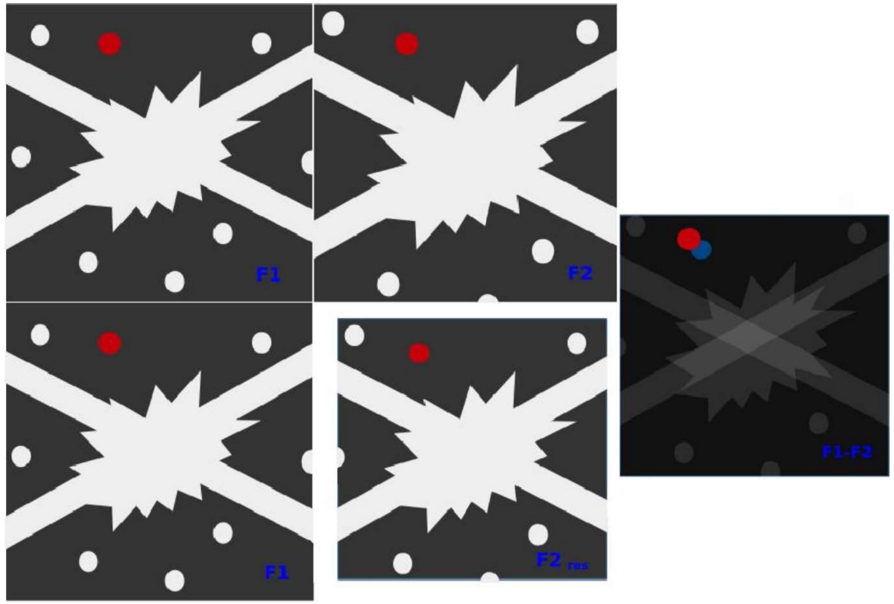


Differential imaging techniques: Contrast ~ 10^{-6}

High contrast differential imaging techniques

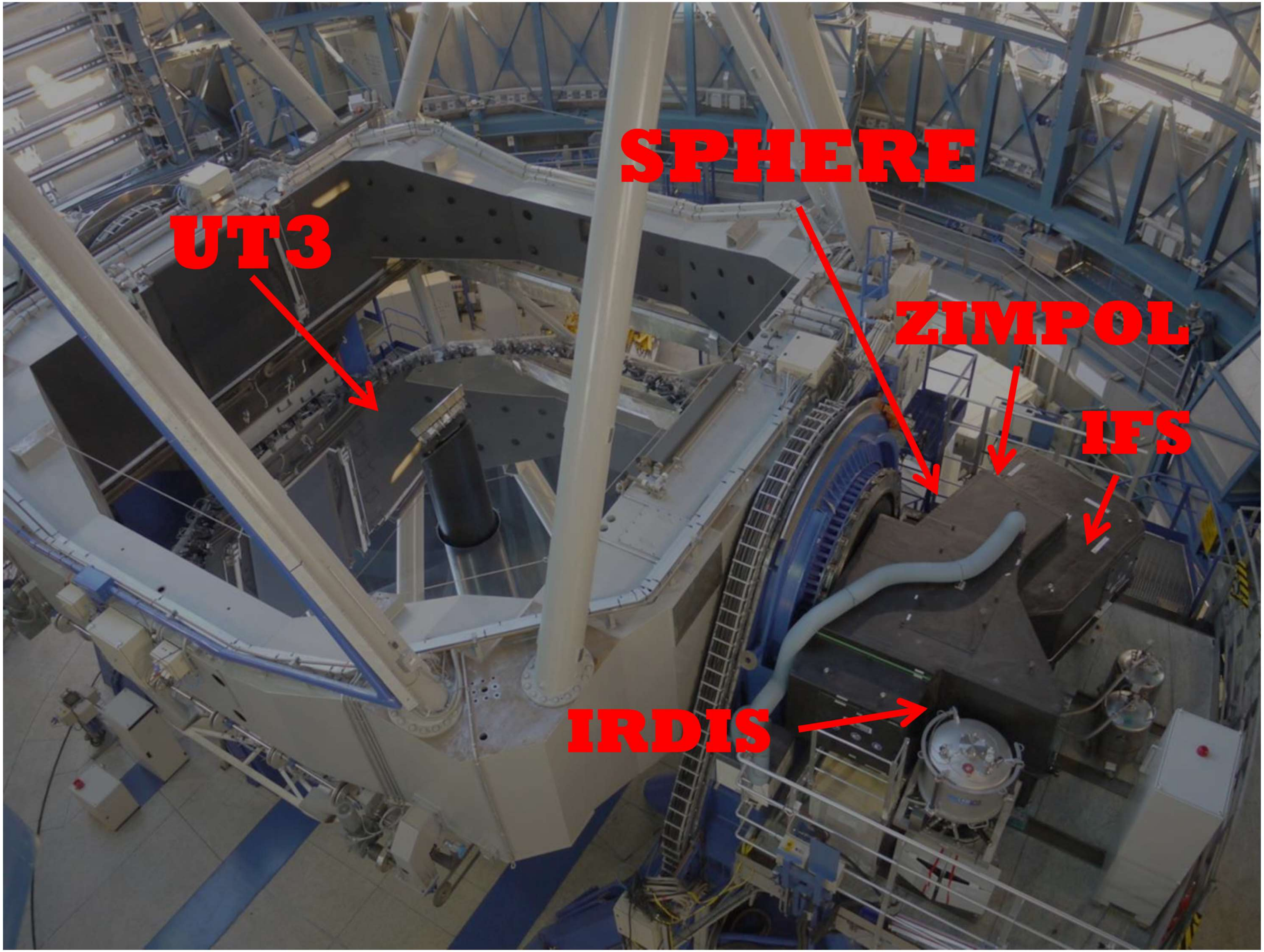


Angular differential imaging (ADI)

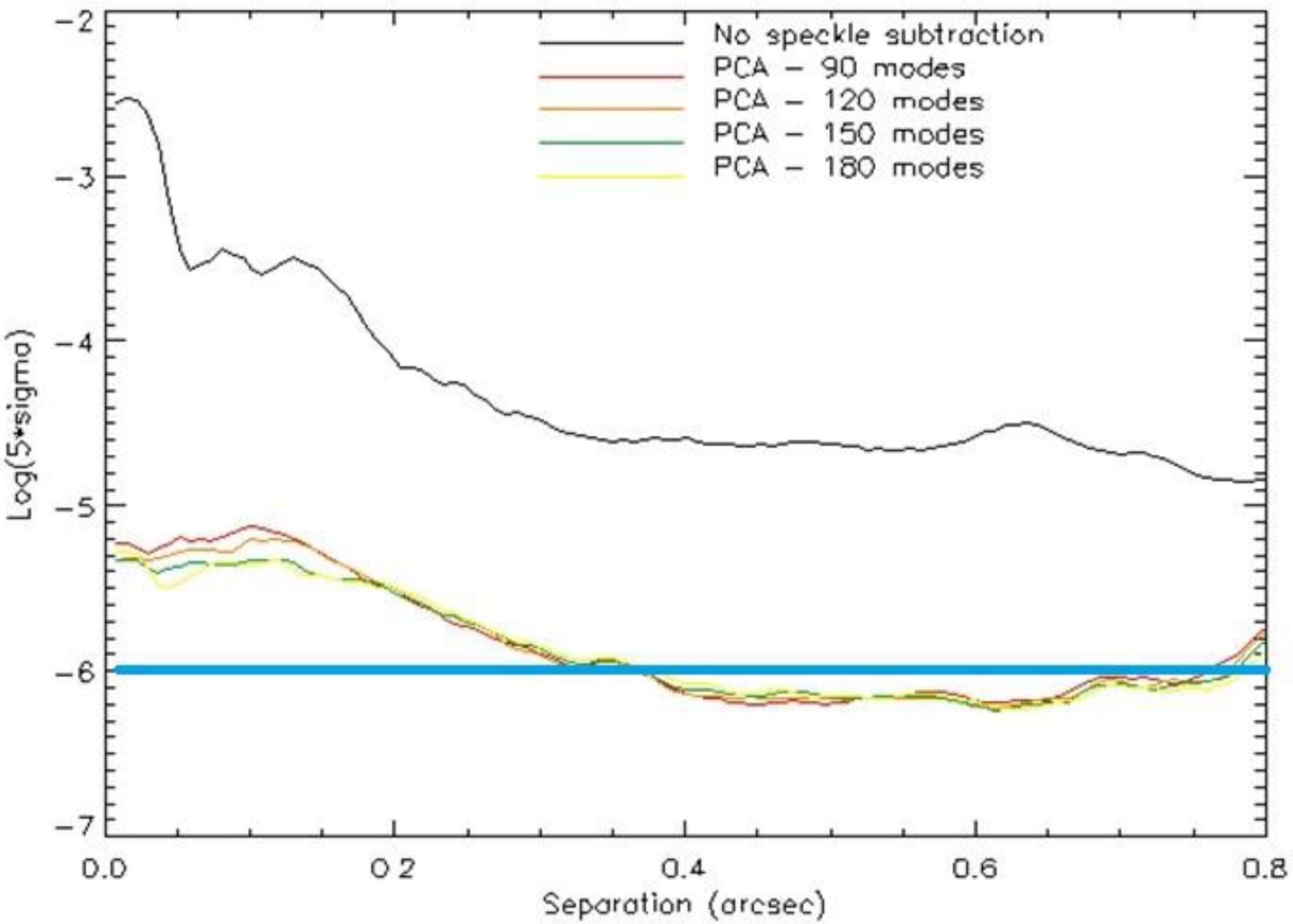


Spectral differential imaging (SDI)

- **Both the techniques can be implemented with SPHERE**
- **Different possible algorithms (e.g. TLOCI, PCA)**

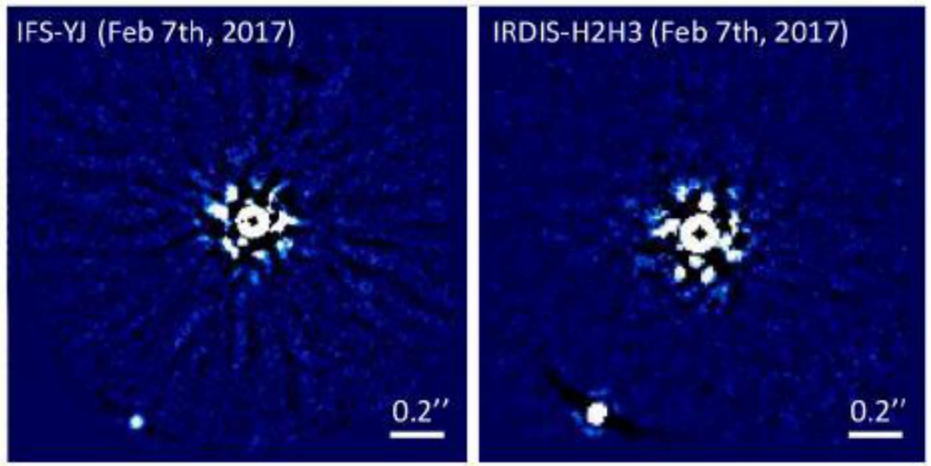

SPHERE
UT3
ZIMPOL
IFS
IRDIS

Results with SPHERE: contrast



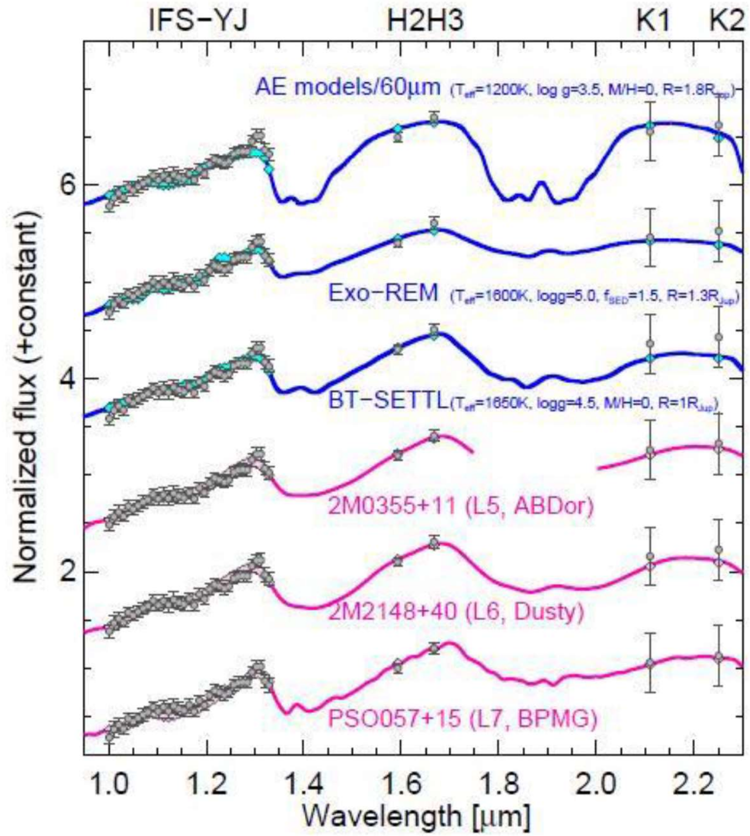
IFS 5σ contrast at 0.3 arcsec ~10^{-6} for Tau Ceti (R=2.88)

First planet detected: HIP65426



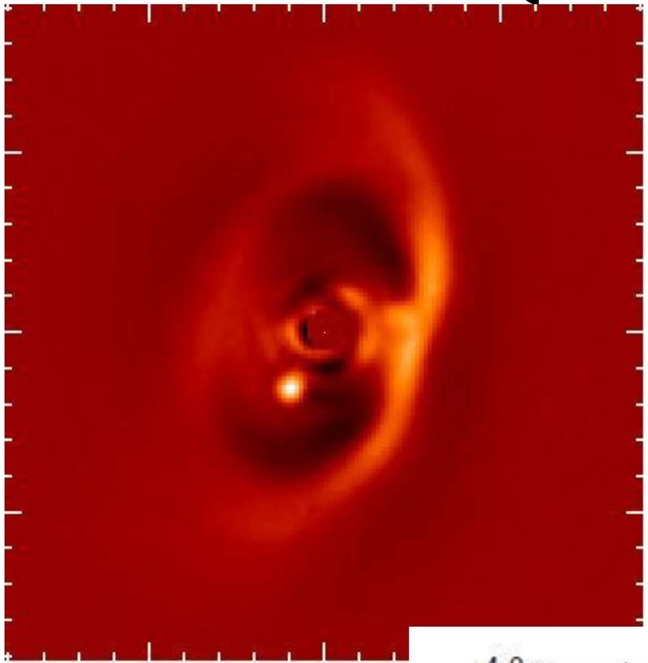
Chauvin et al. 2017

HIP65426:
- A2 spectral type
- d ~ 114 pc
- Age ~ 14 Myr



Companion:
- Spectral type: L7
- $M \sim 7\ M_{jup}$
- $T_{eff} \sim 1500$ K

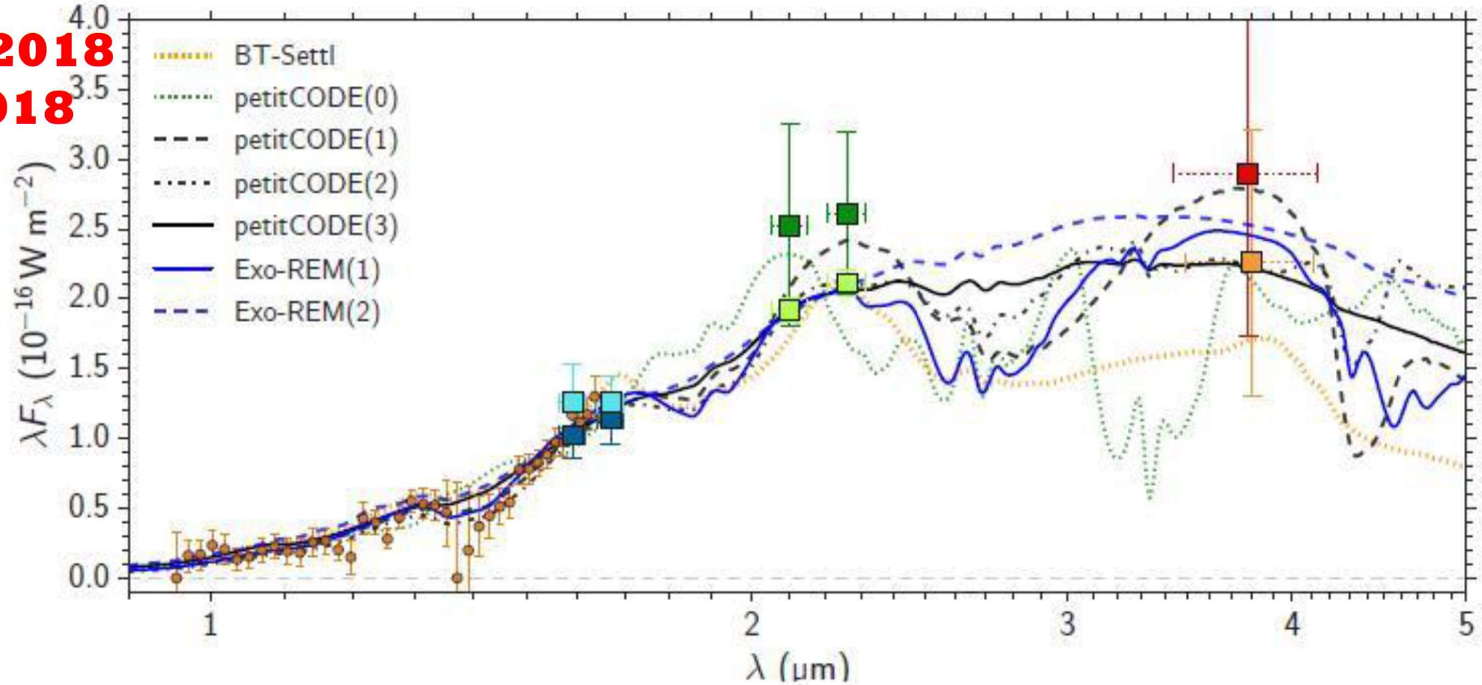
Second (third?) planet detected: PDS70



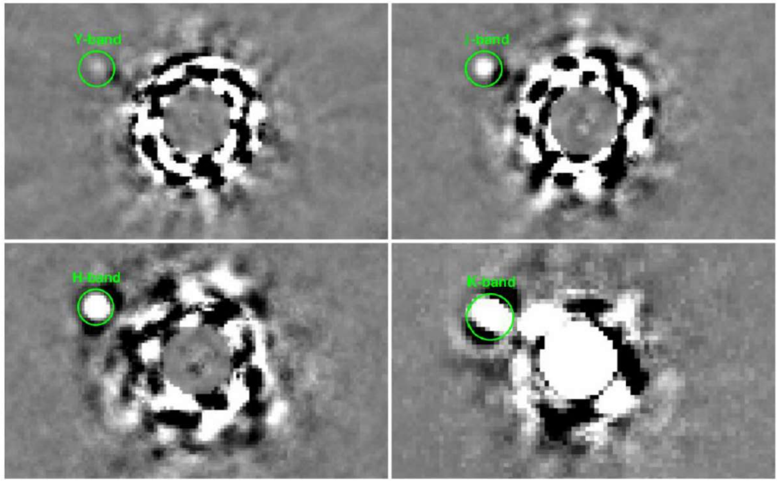
PDS 70:
- Spectral type: K7
- d ~ 113 pc
- Age = 5.4 Myr

PDS 70 b:
- Separation ~ 22 au (into the gap of the protoplanetary disk)
- Mass: 5-9 M_{jup}
- T_{eff}: 1000-1600 K

Keppler et al. 2018
Muller et al. 2018



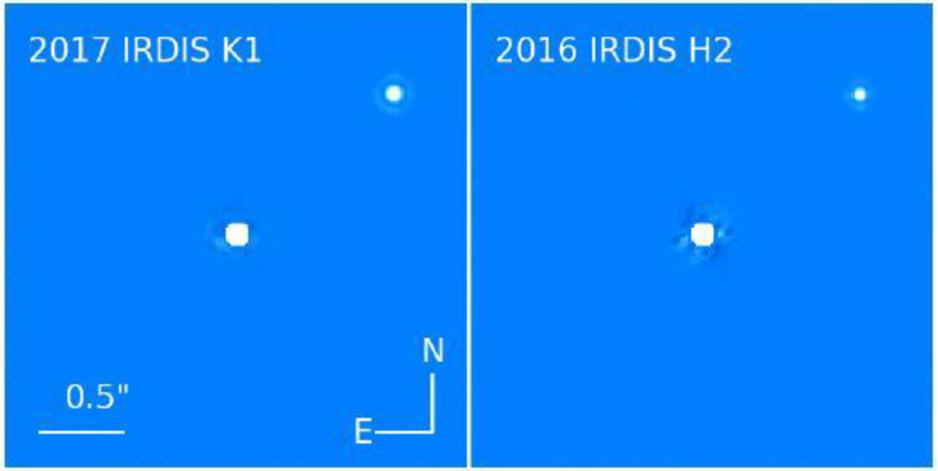
Brown dwarfs



HD206893: F5 star at ~ 40 pc.
Age ~ 250 Myr.

HD206893B: separation ~ 0.27”; M = 15 – 30 M_{jup}.
Spectral type: L5-L7
Very red spectrum → dust in the atmosphere.

Milli et al. 2017
Delorme et al. 2017

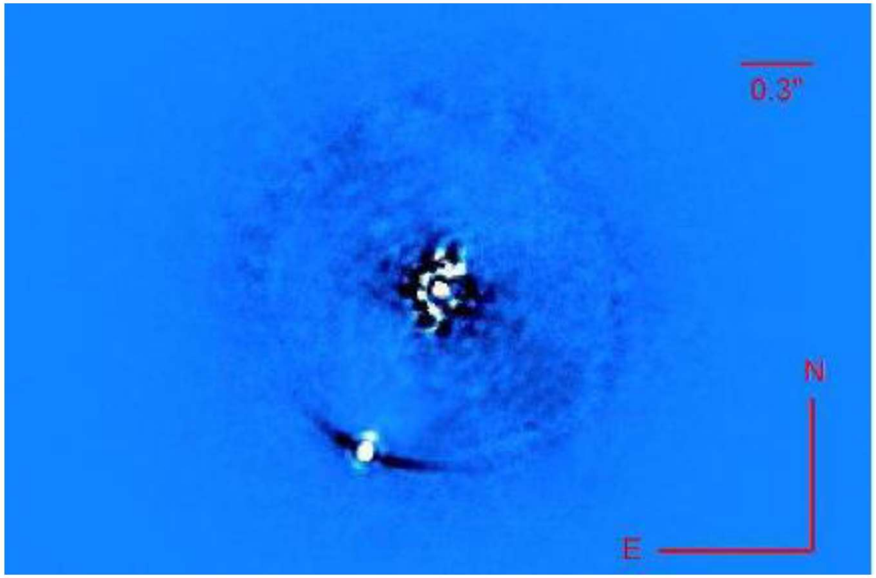


HIP64892: B9.5 star at ~ 125 pc.
Age ~ 16 Myr.

HIP64892B: separation 1.25” (~159 au). M = 29-37 M_{jup}.
Spectral type: M9
T_{eff} ~ 2600 K

Cheetam et al. 2018

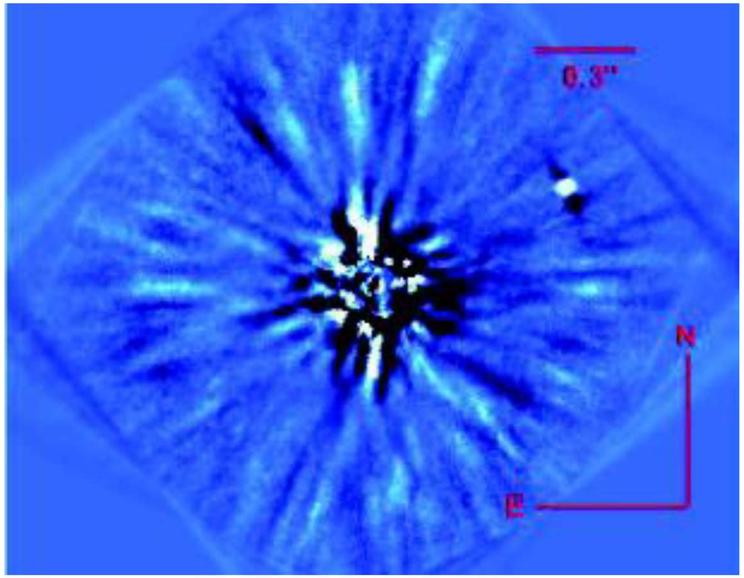
Characterization of known companions



HR3549: A0 star at 92 pc.
Age: 100-150 Myr. Known companion (Mawet et al. 2015)

SPHERE LSS mode allowed a much better characterization: Spectral type M9-L0. $M=40\text{-}50\ M_{jup}$. $T_{eff} \sim 2300\text{-}2400$ K.

Mesa et al. (2016)

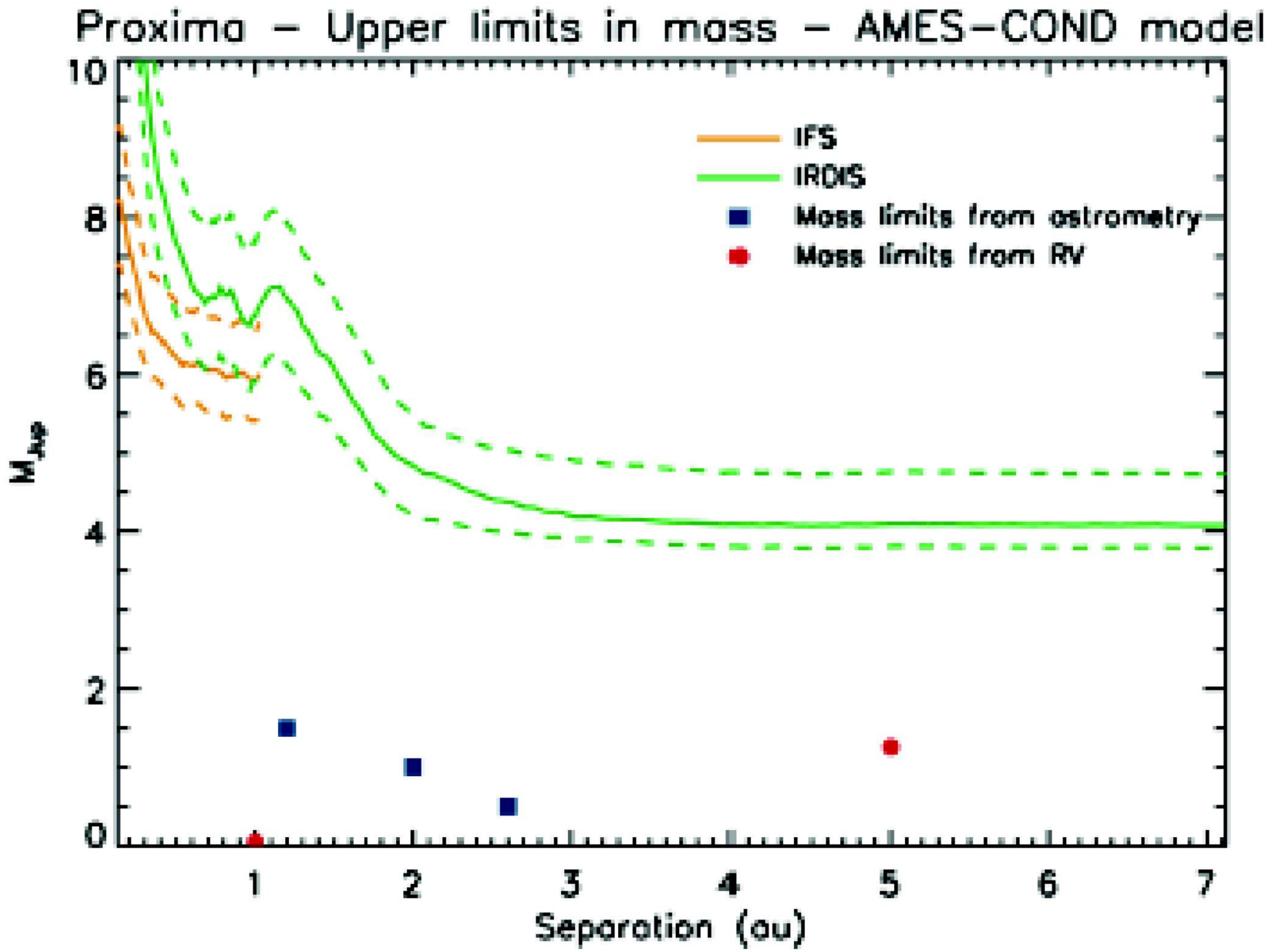


HR2562: F5star at 33 pc.
Age ~ 450 Myr. Known companion (Konopacky et al. 2016)

SPHERE exploited also Y band → T2.5 spectral type; $M \sim 32\ M_{jup}$. $T_{eff} \sim 1100$ K. The companion is at ~ 20 au (into the disk cavity).

Mesa et al. (2017)

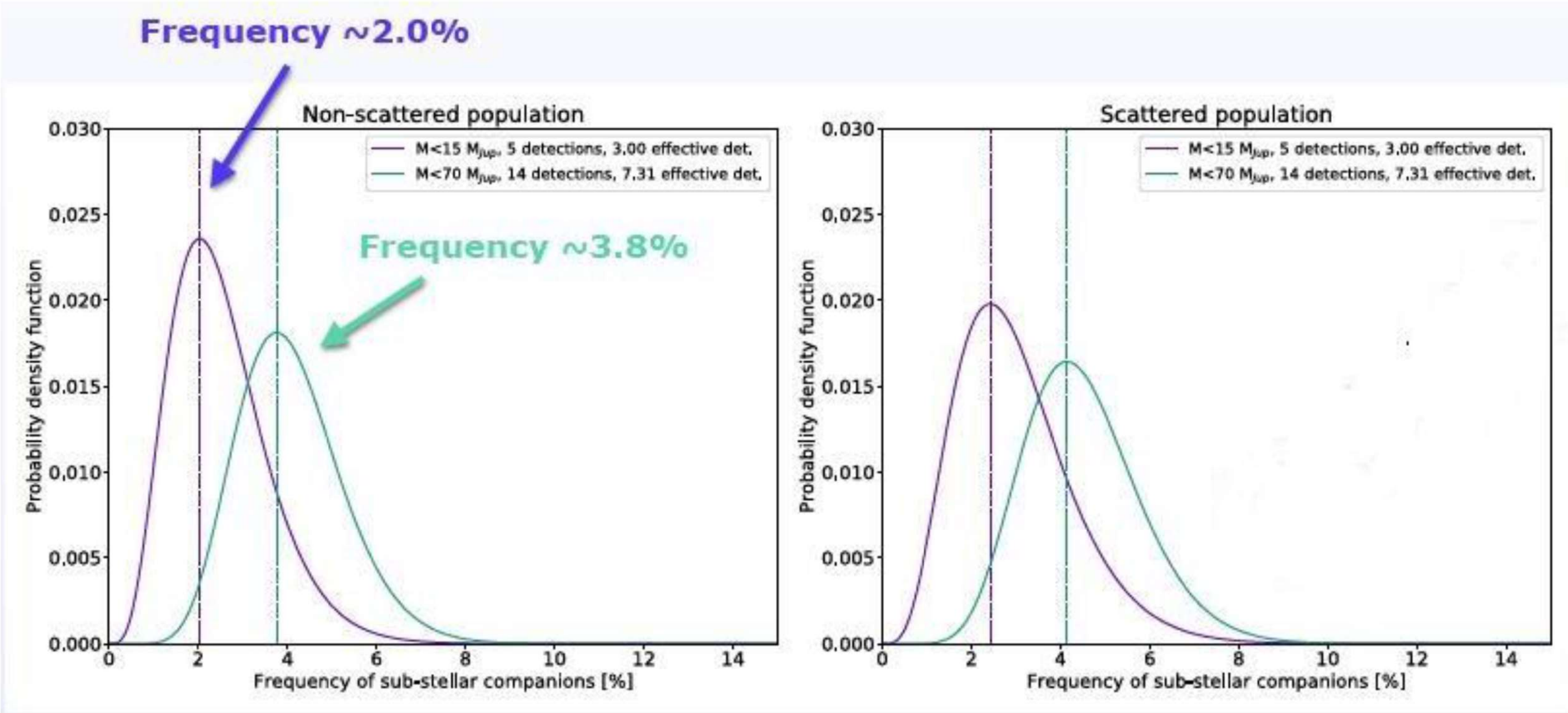
In case of non-detection...



... it is however possible to put limit on the mass of possible companion around the star. Here for Proxima.

Mesa et al. (2016)

Statistical analysis



- **Intermediate sample (167 targets) paper almost ready.**
- **Frequency estimation similar to what found with NACO-LP (Vigan et al. 2017)**
- **The inclusion of scattering do not alterate the results.**
- **Full analysis for 2020-2021**