Scientific preparation of SPHERE planet search survey

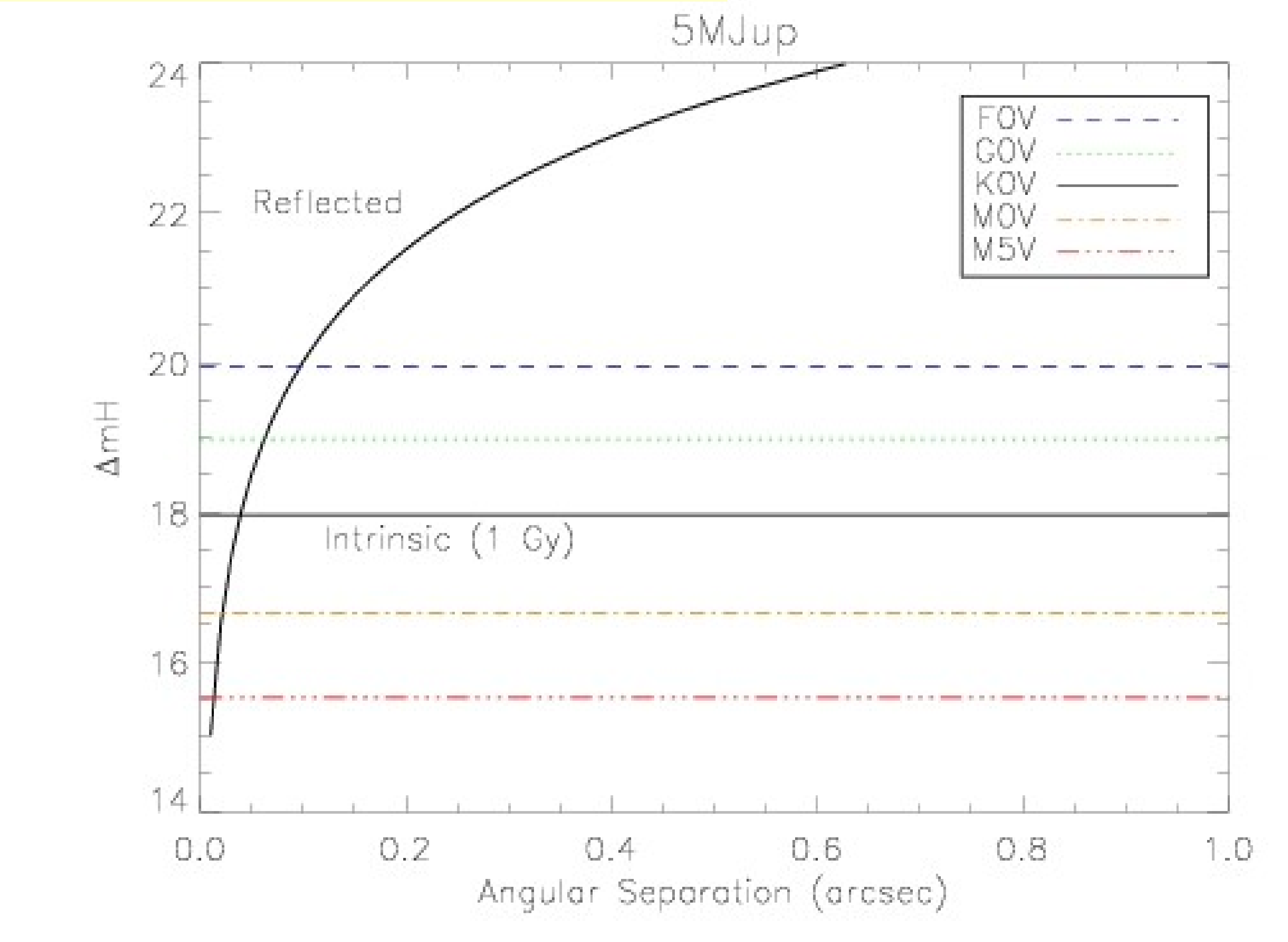
Outline:

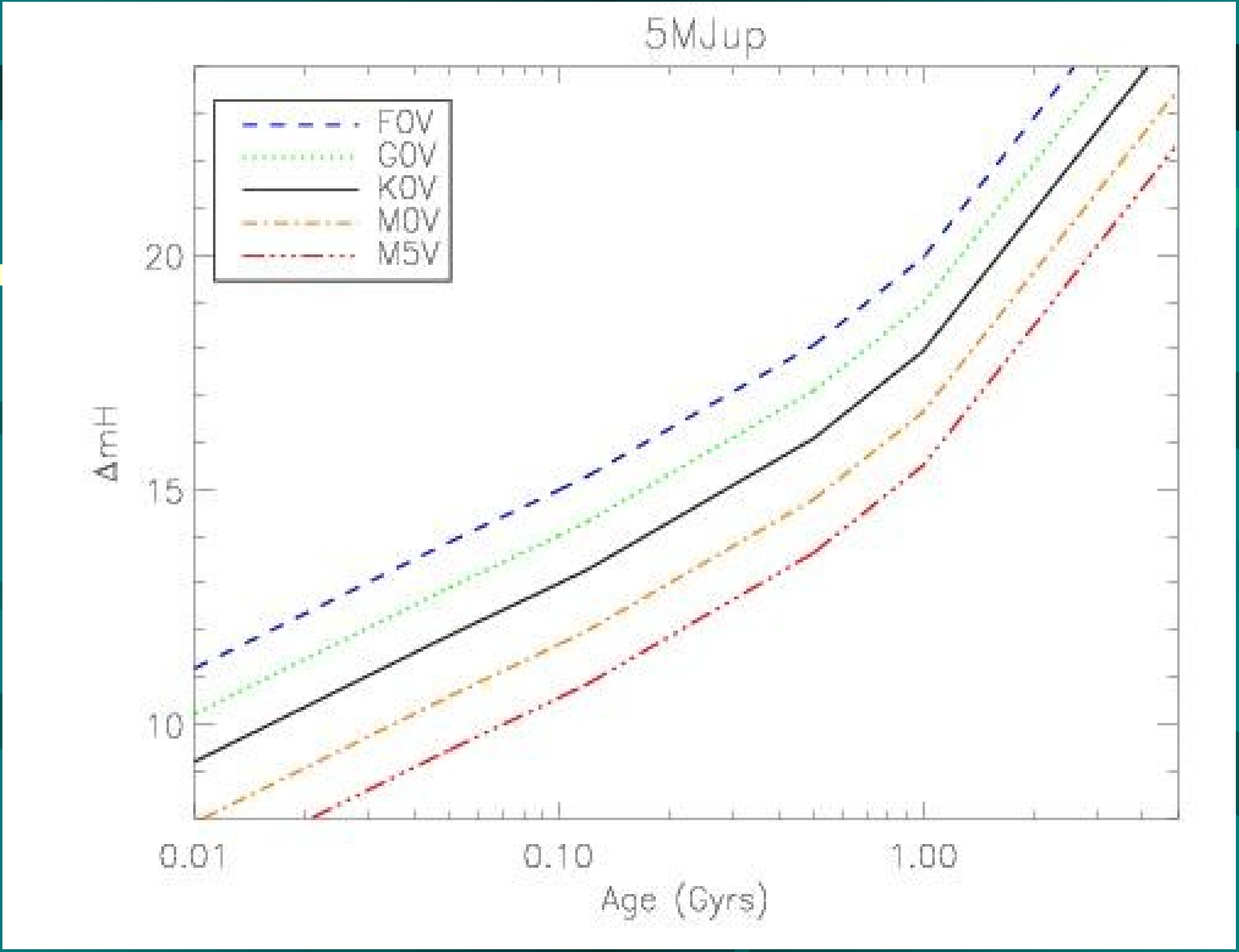
- The challenge of Direct Imaging in the search of extrasolar planets
- SPHERE: the planet finder of VLT
- Making the SPHERE Survey sample

By direct imaging of extrasolar planets we can detect two type of emission:

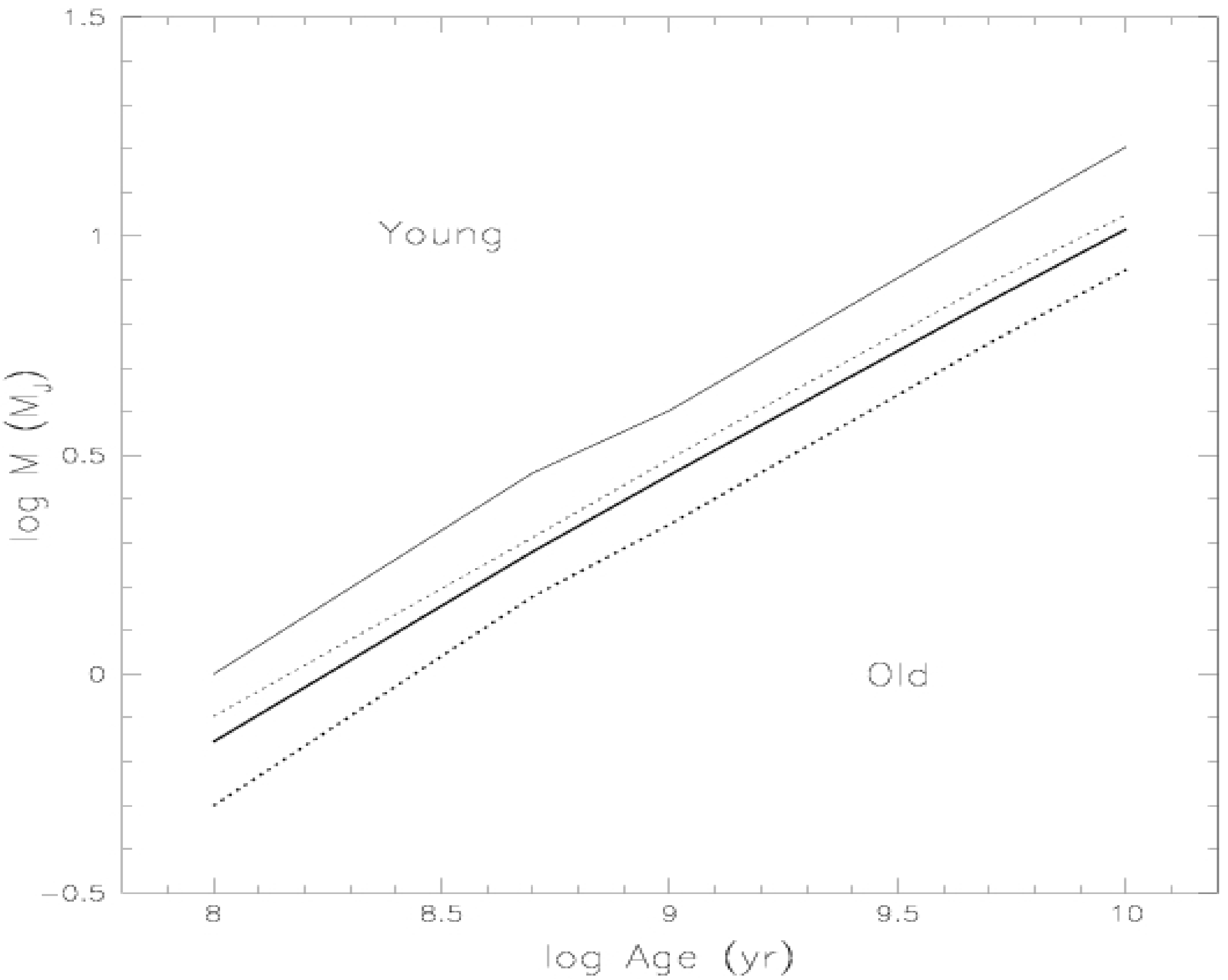
- Intrinsic emission of the planet
- Emission due to the reflection of starlight by atmosphere of the planet

- ***"Young" planets***, dominated by the intrinsic (thermal) emission
- ***"Old" planets***, that shine mainly thanks to the reflected light





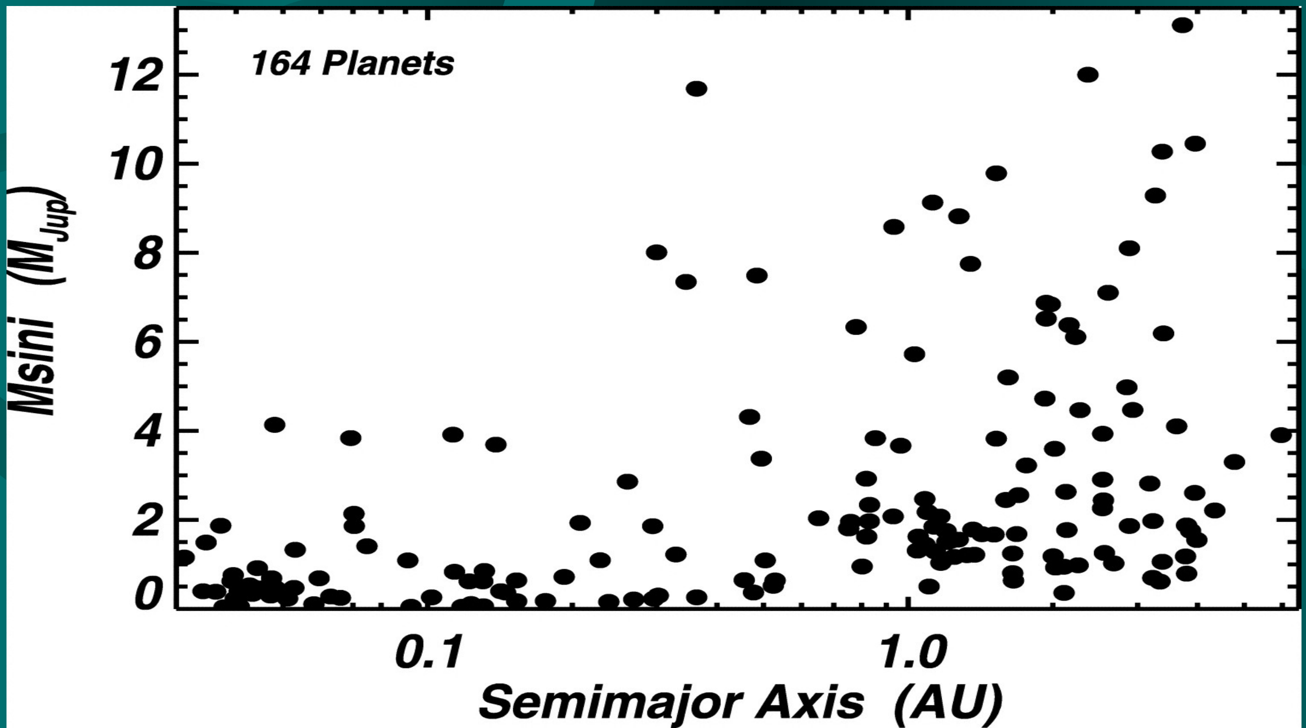
5MJup
F0V
G0V
K0V
M0V
M5V
ΔmH
20
15
10
0.01
0.10
1.00
Age (Gyrs)



1.5
1
0.5
0
−0.5
8
8.5
9
9.5
10
log M (M_J)
log Age (yr)
Young
Old

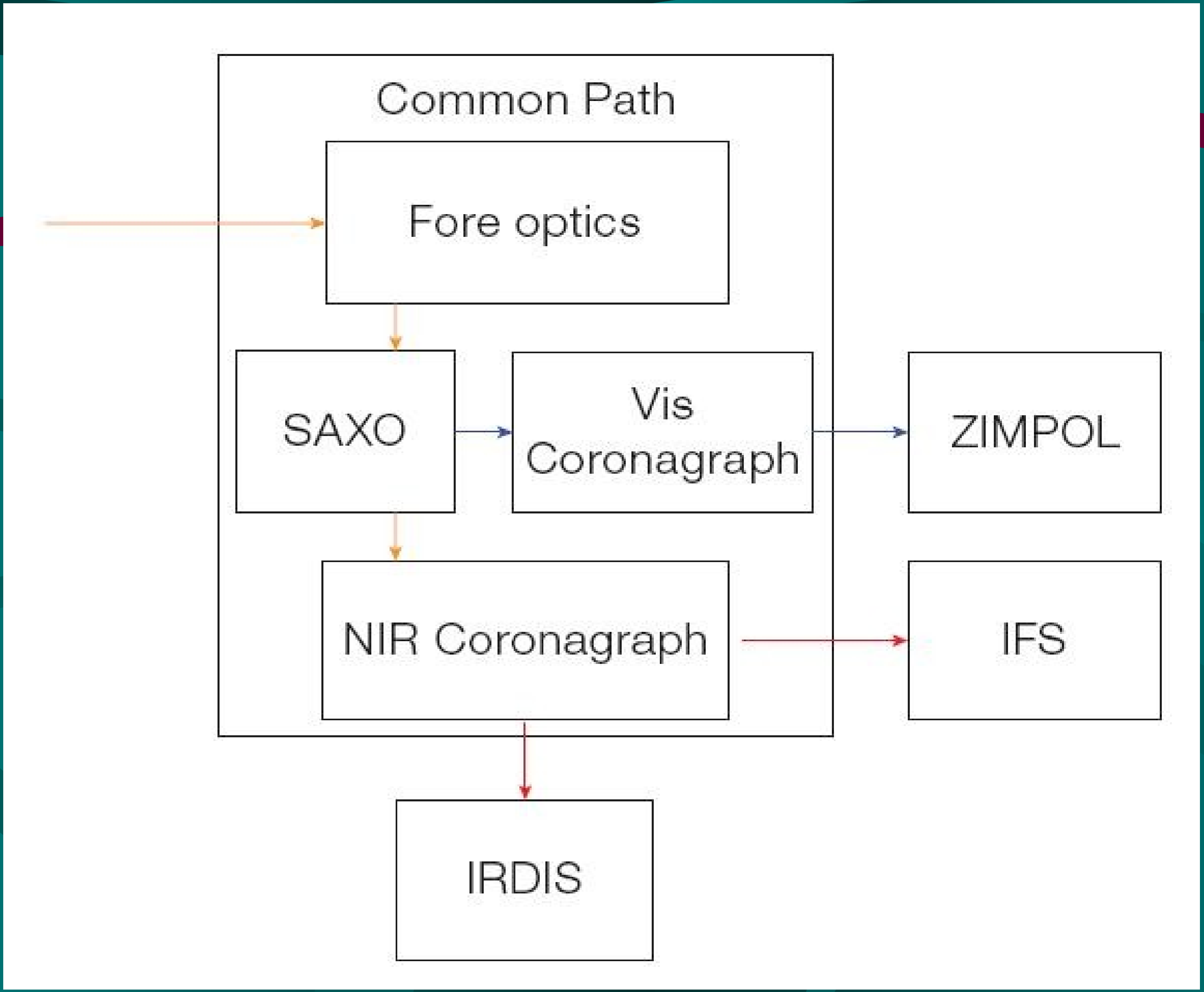
Up to now, the best method to detect close (< 4 AU) substellar companions has been the RV technique.
However, this method is currently insensitive to larger separations and biased against young objects because of their high level of activity..
To understand the way(s) EGPs and BDs form and evolve, we need to extended our sensitivity to longer periods and to lower masses.

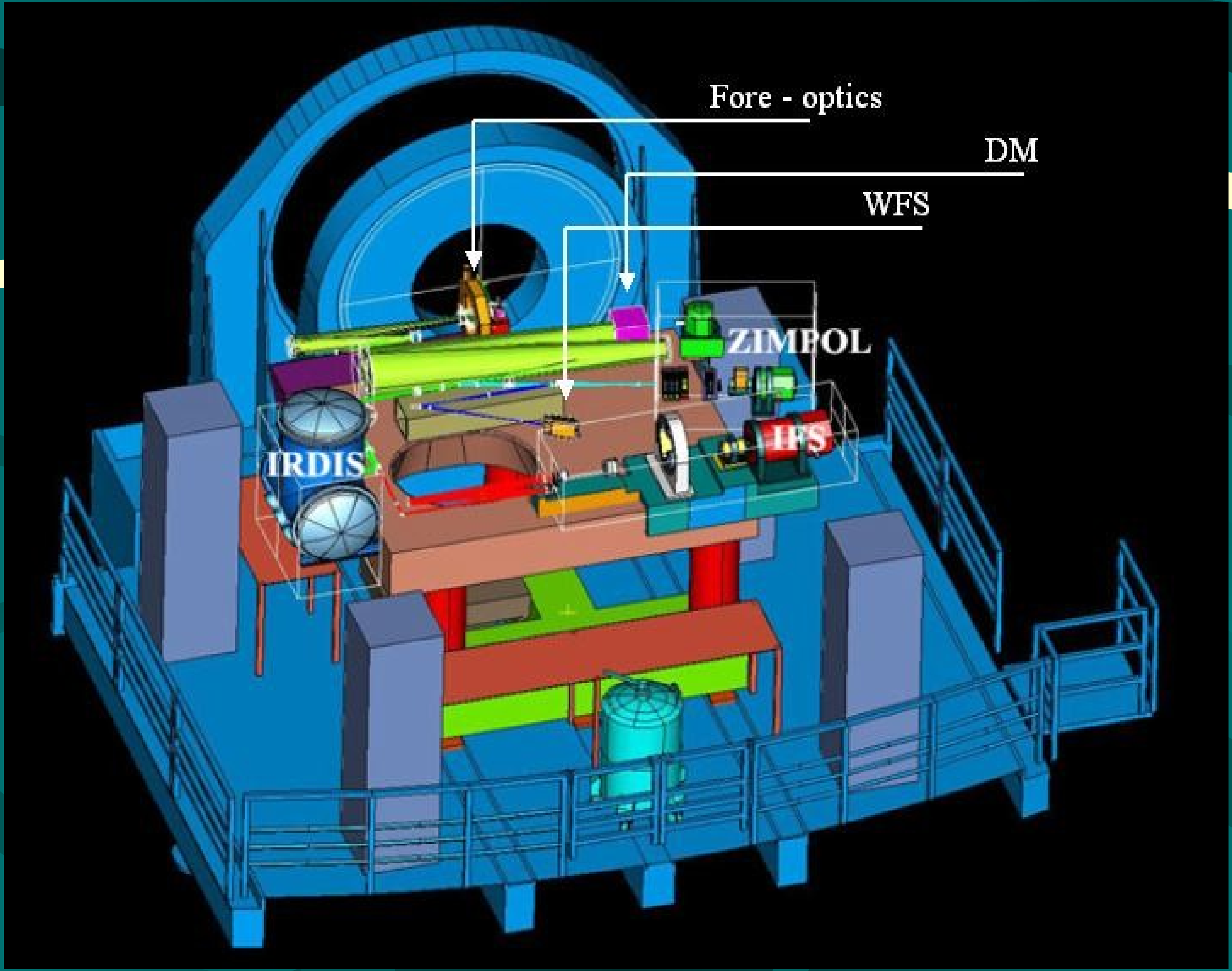
With the development of high contrast and high angular resolution imaging, we could rapidly probe the characteristics of EGPs and BDs at larger separations (typically >50—100 AU).



SPHERE is a second-generation VLT instrument composed by:

- Extreme Adaptive Optics (SAXO)
- Achromatic phase-mask coronographs (Vis + NIR)
- Differential imaging capability using:
  - Dual band imaging (IRDIS)
  - Integral Field Spectroscopy (ISF)
  - Differential polarization imaging (ZIMPOL)


Common Path
Fore optics
SAXO
Vis
Coronagraph
ZIMPOL
NIR Coronagraph
IFS
IRDIS


Fore - optics
DM
WFS
ZIMPOL
IFS
IRDIS

Science with SPHERE

Primary scientific Goal:
Discovery and study of new extrasolar planets orbiting nearby stars by direct imaging of their circumstellar environments.

The present indication that massive distant planets could be numerous would be firmly confirmed or denied by SPHERE detection, if the number of observed target with relevant detection limits is statistically acceptable, i.e. of the order of 300 to 400.

This would in particular fully justify a large effort in an extended observational survey of several hundred nights concentrating on the following classes of target:

- ❑ Nearest stars (3-20 pc)
- ❑ Nearby young association (20-70 pc, 1-100 My)
- ❑ Intermediate stars (3-50 pc, 0.1-1 Gy)
- ❑ Stars with known planets

Making the sample

Preliminary sample:

- Very young stars in association at less than 100 pc
- Few young (< 1 Gy) solar-type stars
- Several tens of bright and nearby stars, up to 20 pc
- A few dozen of M "southern" dwarfs, earlier than M4 and within 12 pc
- Stars with detected planets

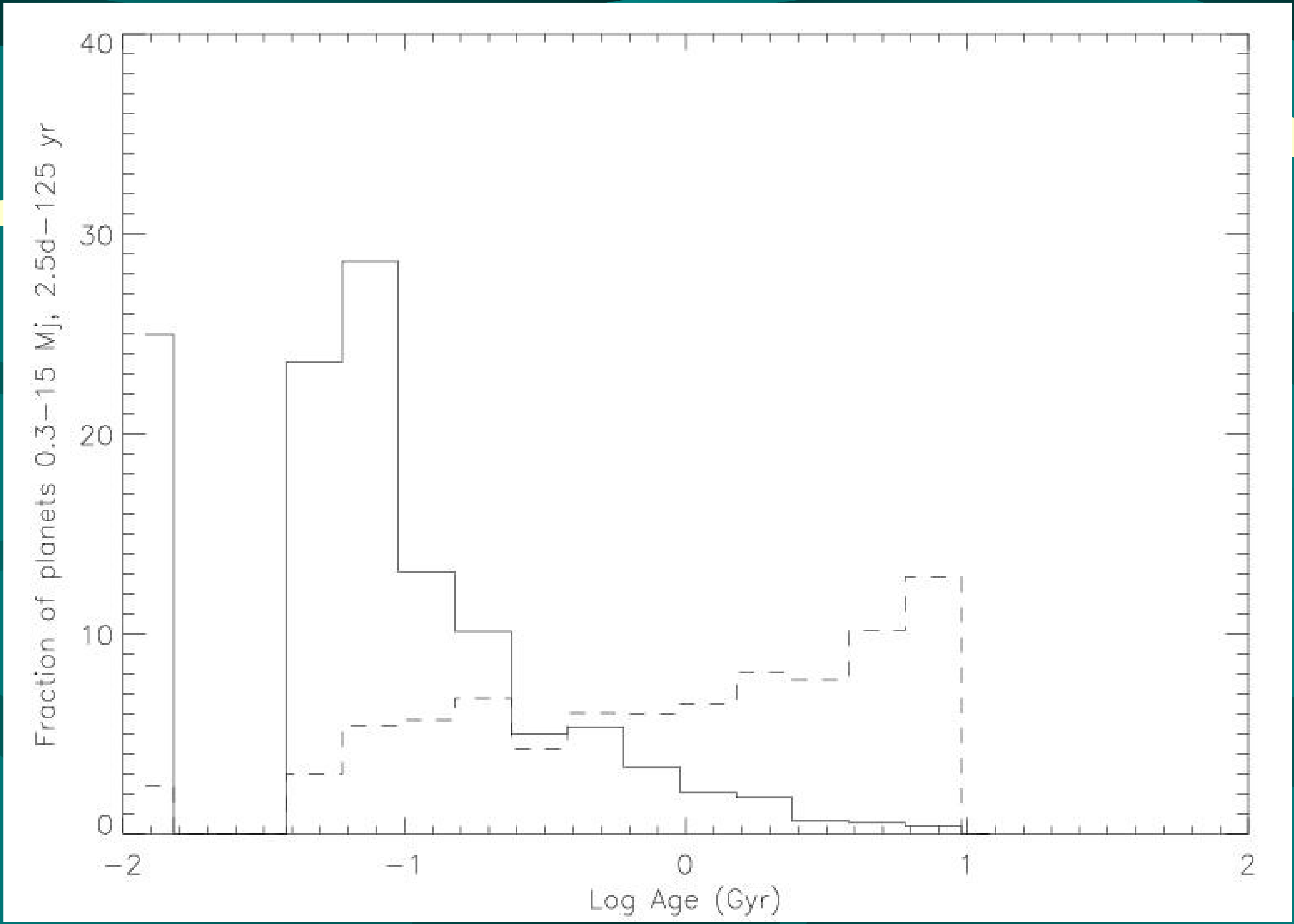
- ❖ Analyzing the detection performances of the instrument
- ❖ Estimating the number of targets suitable for planet search via direct imaging
- ❖ Evaluating how do planetary and stellar characteristics combine in the detection space of SPHERE

Preparatory observations

- ➢ Spectroscopic characterization
- ➢ Deep imaging
- ➢ RV monitoring
- ➢ Parallaxes measurement

Simulation of the chance of planet detection with SPHERE

- Normalization of the planet frequency according with stellar metallicity
- Random generation of all orbital elements and masses according with the adopted distributions
- Evaluation of observable parameters, according with the detection technique selected
- Evaluation of detectability, excluding planets not dynamically stable (in case of binary systems)



Fraction of planets 0.3−15 Mj, 2.5d−125 yr
40
30
20
10
0
−2
−1
0
1
2
Log Age (Gyr)

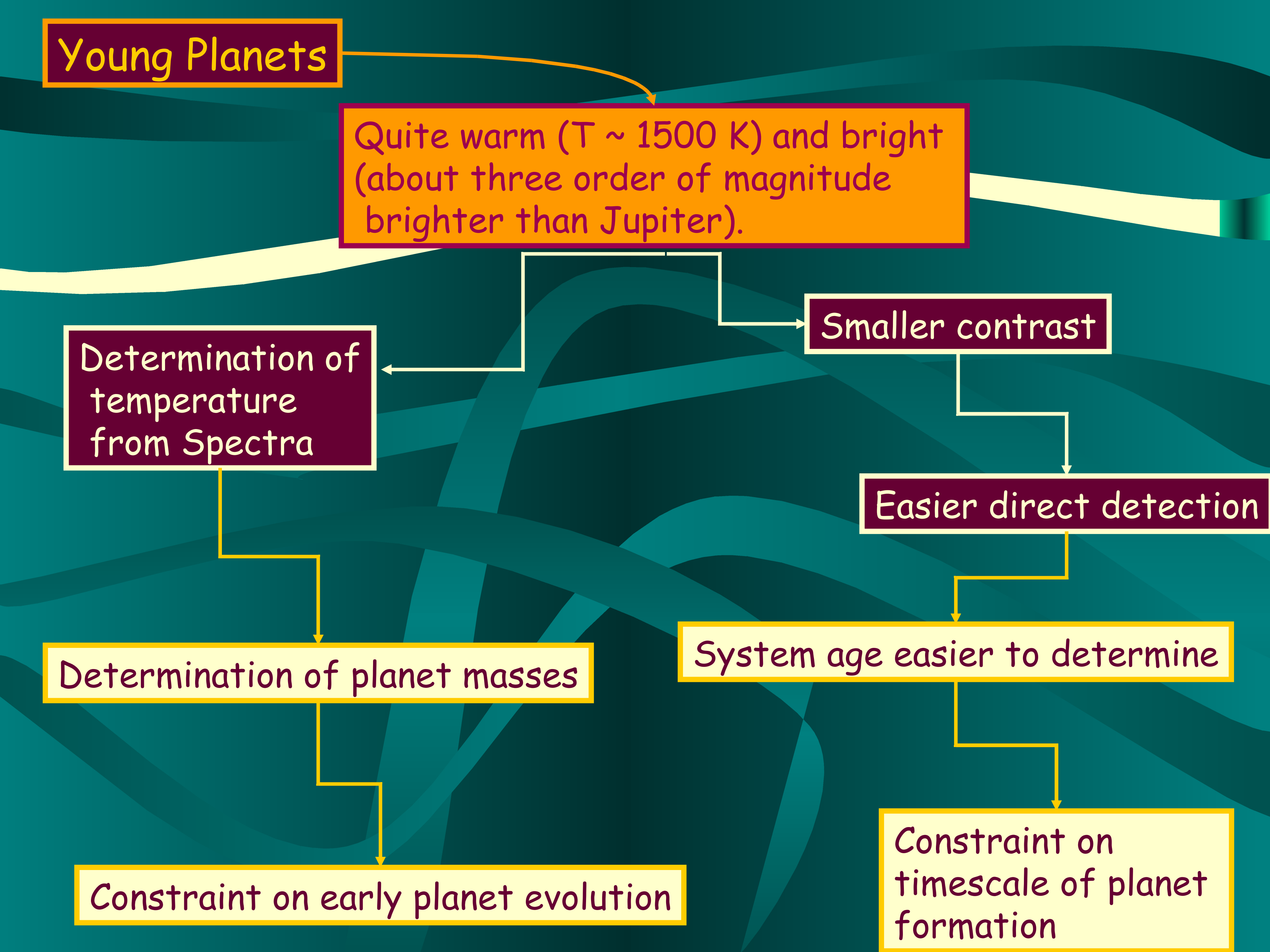
Conclusions

The final objective is to better define the detection space of SPHERE, evaluating what kind of target are achievable and what fraction of the sample must be selected without bias

Making a sample including most promising stars selected to obtain high-impact results rapidly.

That's all!!!!

Thank you for attention!


Young Planets
Quite warm (T ~ 1500 K) and bright (about three order of magnitude brighter than Jupiter).
Determination of temperature from Spectra
Smaller contrast
Easier direct detection
Determination of planet masses
System age easier to determine
Constraint on early planet evolution
Constraint on timescale of planet formation

Old Planets

Giant planets close to the snow line in the protoplanetary disk

Their luminosity depends on:
- star-planet distance
- properties of atmosphere (albedo, polarization level)

Old stars hosting distant giant planet around old stars may harbor terrestrial planets in Habitable zones

Clouds characteristics not strongly Mass-dependent

Similar contrast for different masses

Radius weakly depends from Mass

Similar spectra

Optimal observations in I

SPHERE will greatly contribute to the field of extra-solar planet studies, particularly by exploration of the outer part of the planetary systems trough direct detections of planets more massive than Jupiter at various stages of their evolution, in the key separation regime 1 to 100 AU. Migration mechanism will then be better understood.

The complementarities of direct imaging with other methods will offer promising avenues.

Both evolved and young planetary systems will be detected, respectively trough the reflected light (mostly by ZIMPOL) and trough the intrinsic planet emission (using IRDIS ans IFS)