

# IMPROVING DETECTION LIMITS ON HIGH CONTRAST IMAGING : THE PACO ALGORITHM PERFORMANCES

First results on a small survey

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# Introduction

THESIS : Exoplanet detection with high contrast imaging

- Reprocess the entire SPHERE archive
- Use of a new algorithm : PACO
- Test bed on a small sample of close and young solar-type stars

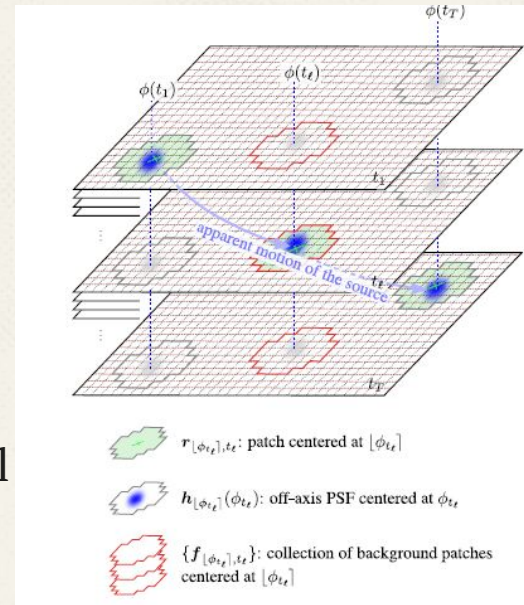
# The PACO algorithm

Algorithm developed to process HCI observation (PAtch COvariance, Flasseur et al. 2018)

- Statistical data-driven modelling of noise at local scale
- Provide statistically-based SNR maps following  $N(0,1)$
- No PSF subtraction step

We used robust PACO ASDI (Flasseur et al. 2020ab)

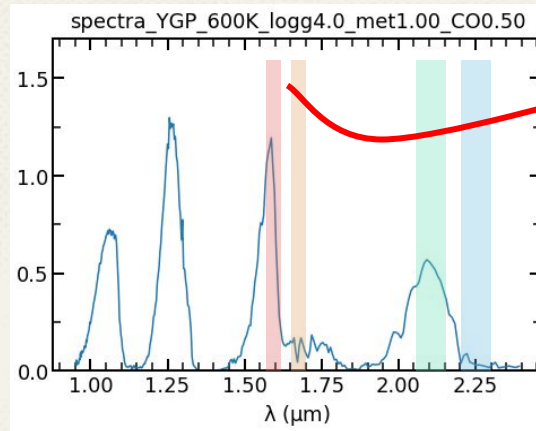
- Robustness to bad frames
- ASDI allow better noise estimation and optimal spectral combination following a prior



## Priors creation for PACO ASDI

Priors are used to optimally combine multi wavelength data following weights → spectral priors, maximize snr of sources

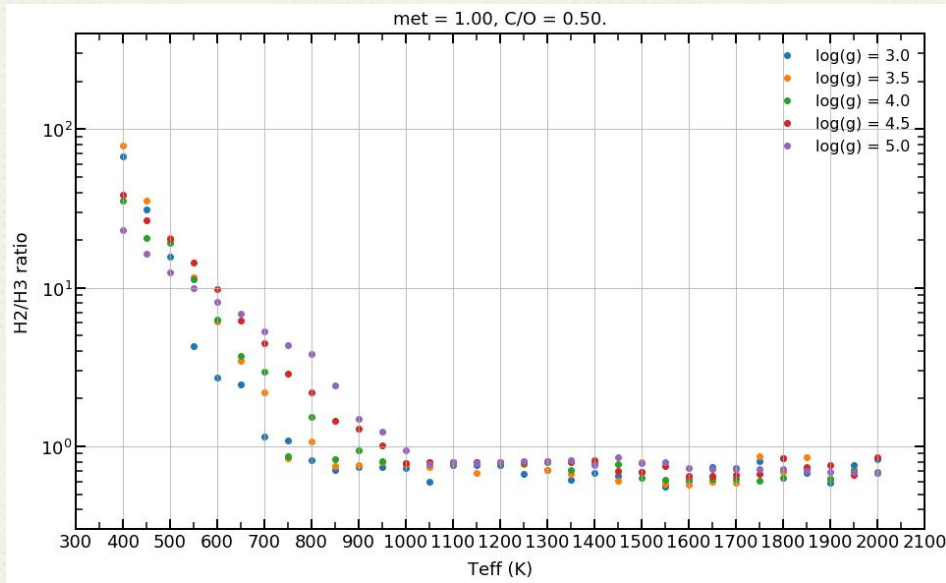
We choose to build our spectral priors based on Exo-Rem model (~10 000 spectra at R=500, Charnay et al. 2019)



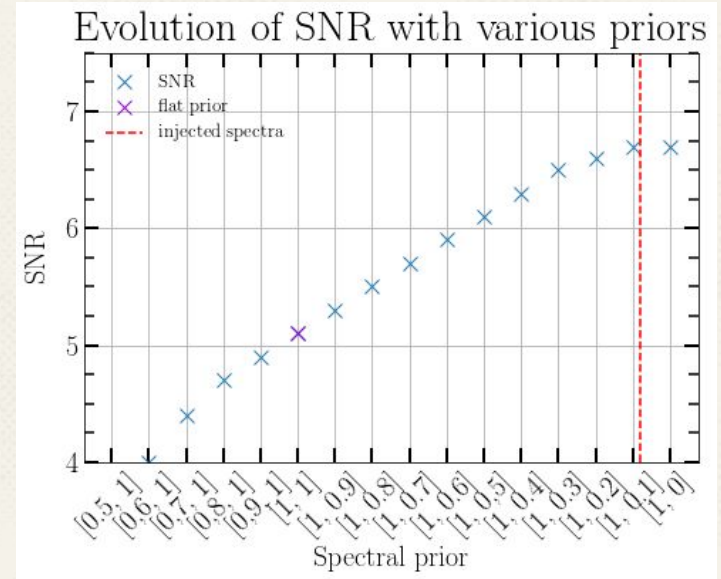


# IRDIS spectral priors

## Exploring the spectral diversity



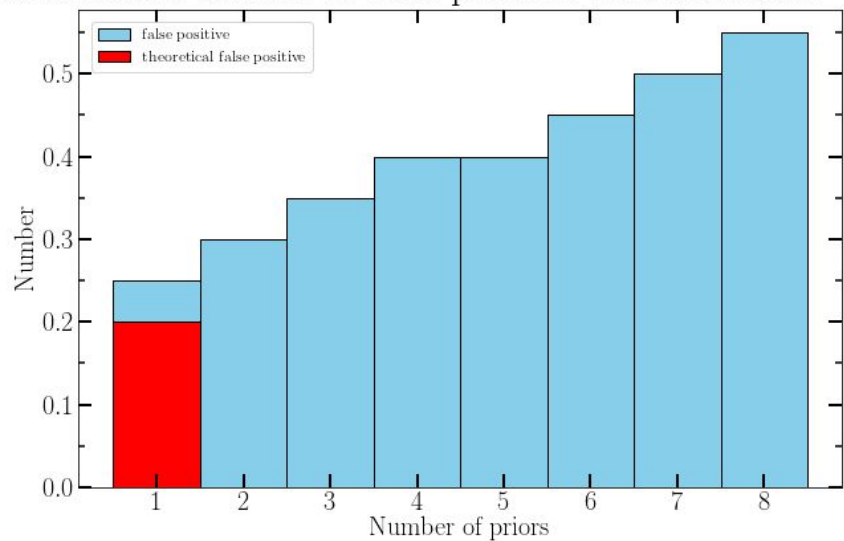
Study the sensibility of PACO to various number of priors with fake injected planet of various spectral types



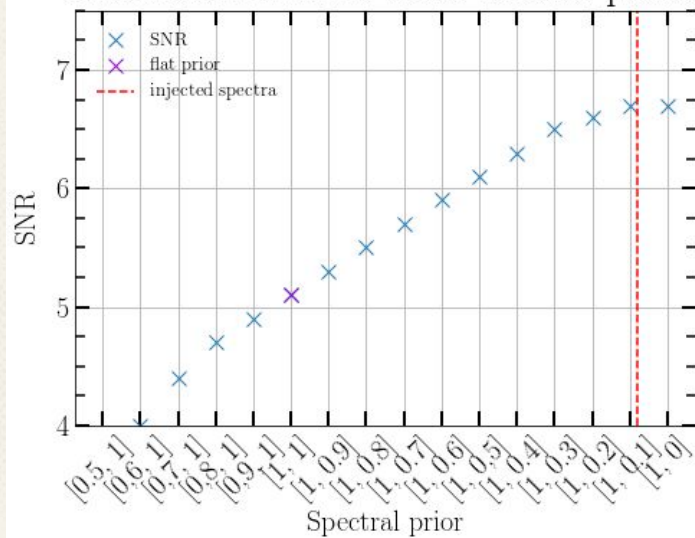
# IRDIS spectral priors

## Impact on false positive rate of adding prior

Normalized number of false positive with threshold = 5.0

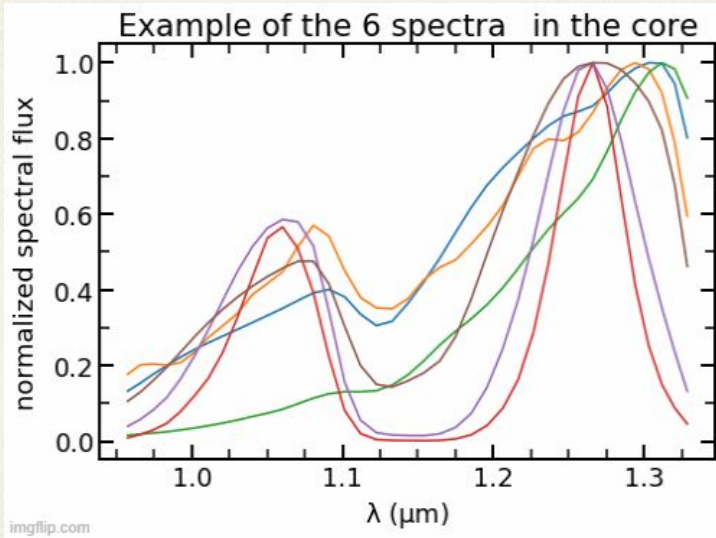


Evolution of SNR with various priors

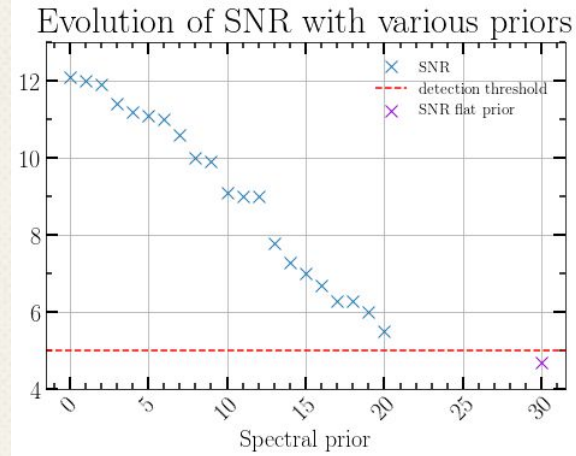
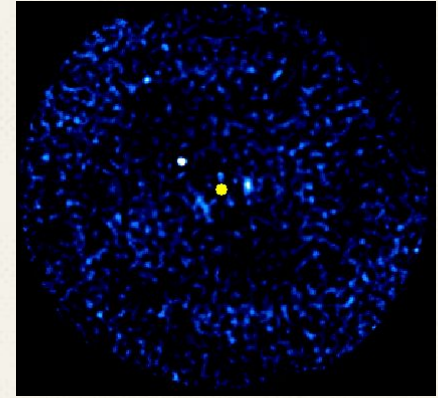


# IFS spectral priors

Euclidian based method to explore the spectral diversity



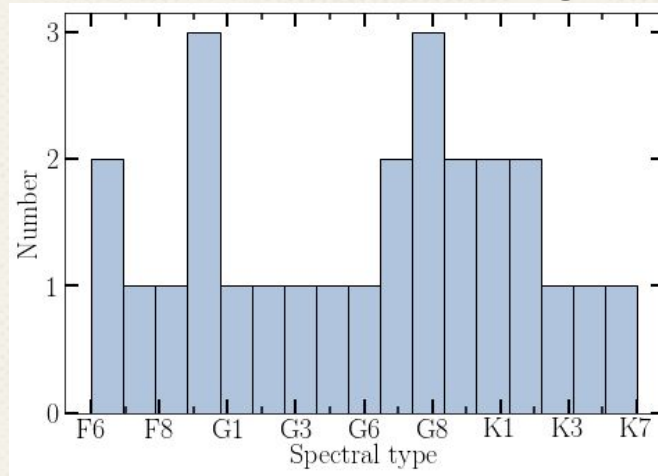
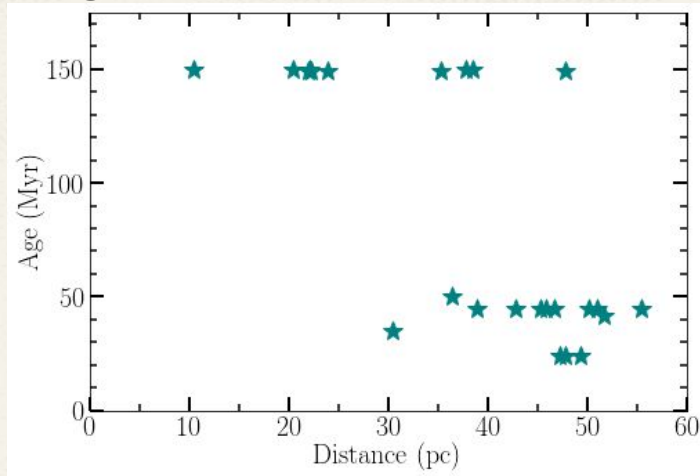
HD206893 b  
2017-07-13  
YJ band



## Mini-survey : sample definition

All (23) young ( $< 150$  Myr), close ( $< 60$  pc) solar type stars observed during the SPHERE/SHINE F150 (part of the SPHERE GTO survey, Desidera et al. 2021) survey with H23/JY filters

Designed as a test bed for the future massive reduction (all targets).



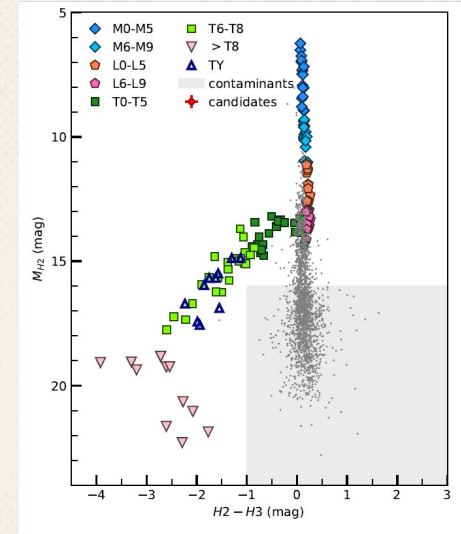
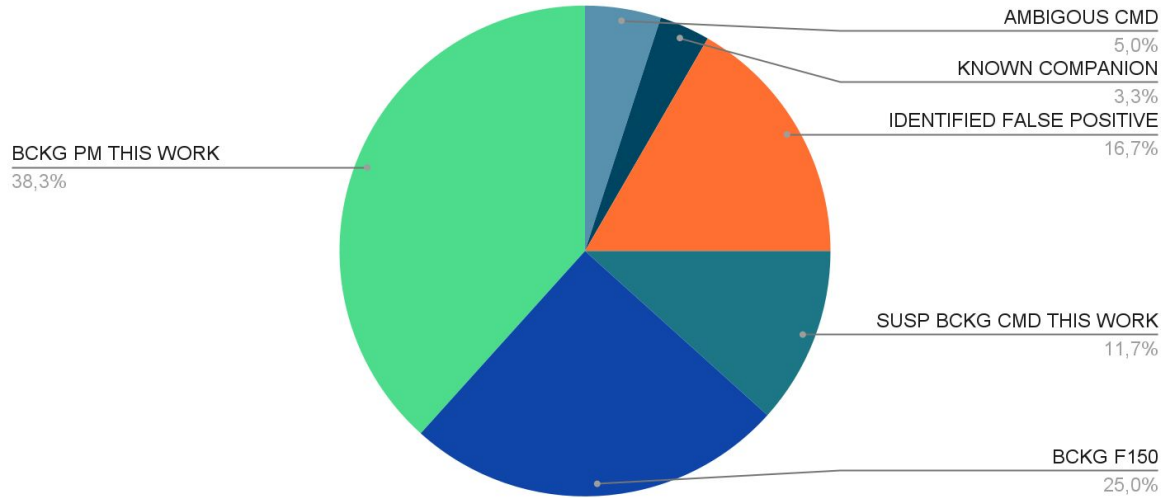


# Results : IRDIS detection classification

60 (20 new) detections above 5 sigma; 40 datasets

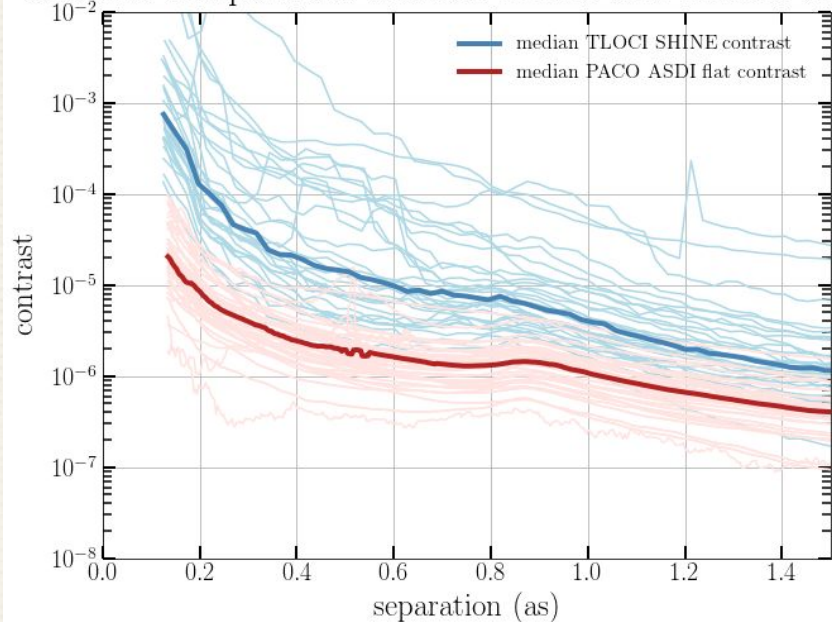
10 false positives, 16 theoretical.  
→ confirm gaussian noise behavior of PACO !

DETECTIONS ABOVE 5 SIGMA

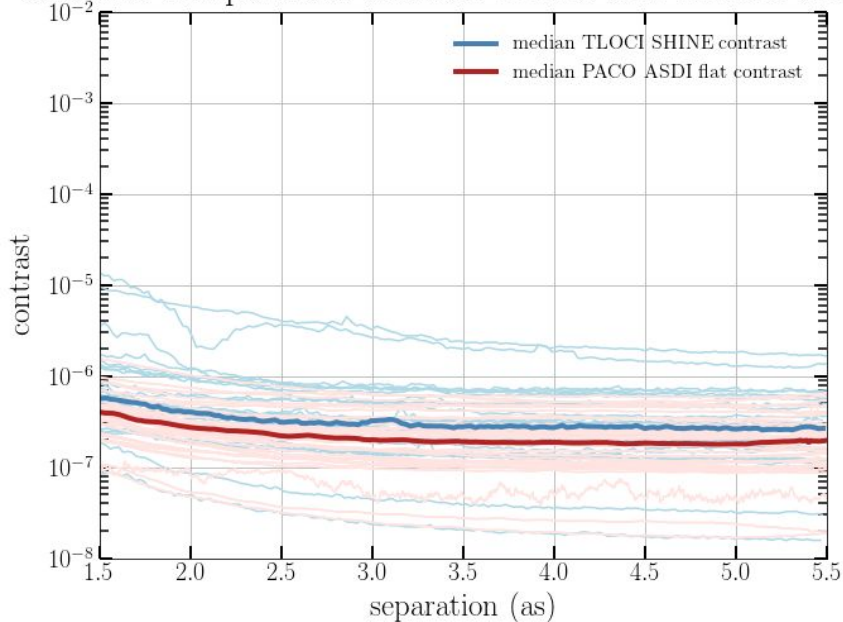


# Results : IRDIS contrast comparison with SHINE F150

Contrast comparison between PACO and TLOCI SHINE

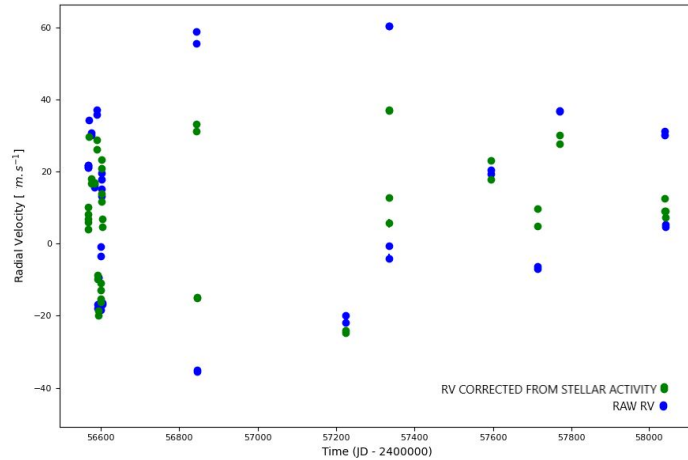


Contrast comparison between PACO and TLOCI SHINE

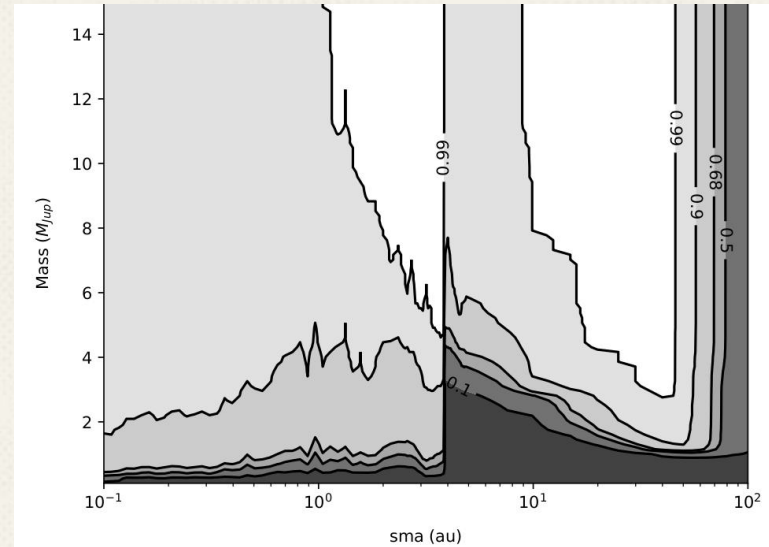


# Results : detection limits using MESS2

HIP13402, 2016-10-14, H23 band, DI+RV combination

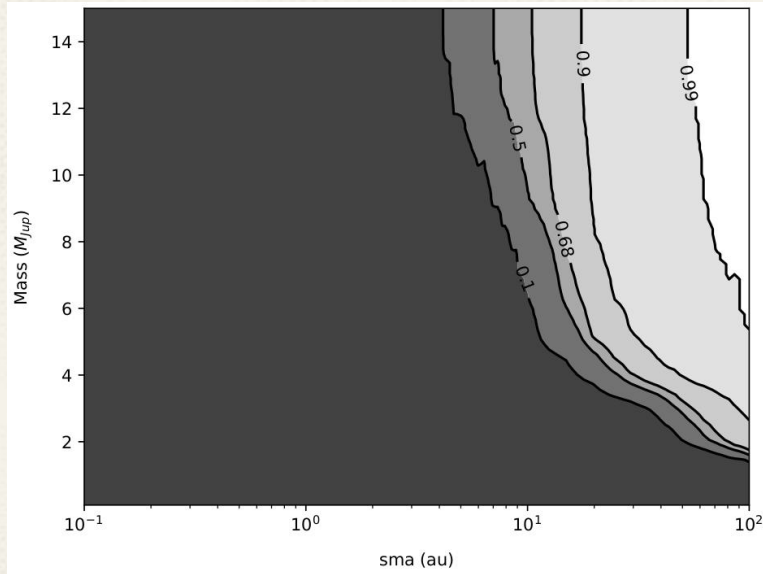


Grandjean et al, 2020

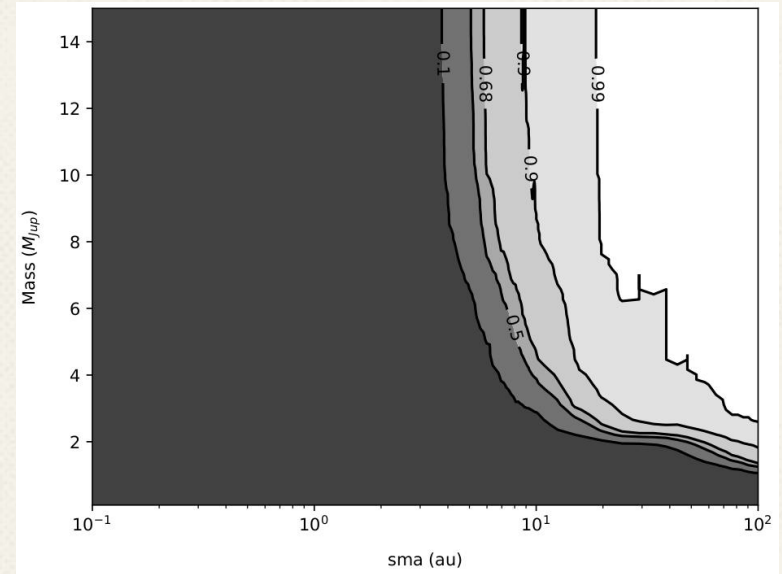


# Results : detection limits using MESS2

HIP 1481, 2015-10-26, H23 band, DI only



HIP 1481, 2015-10-26 + 2016-09-18, H23 band, DI only

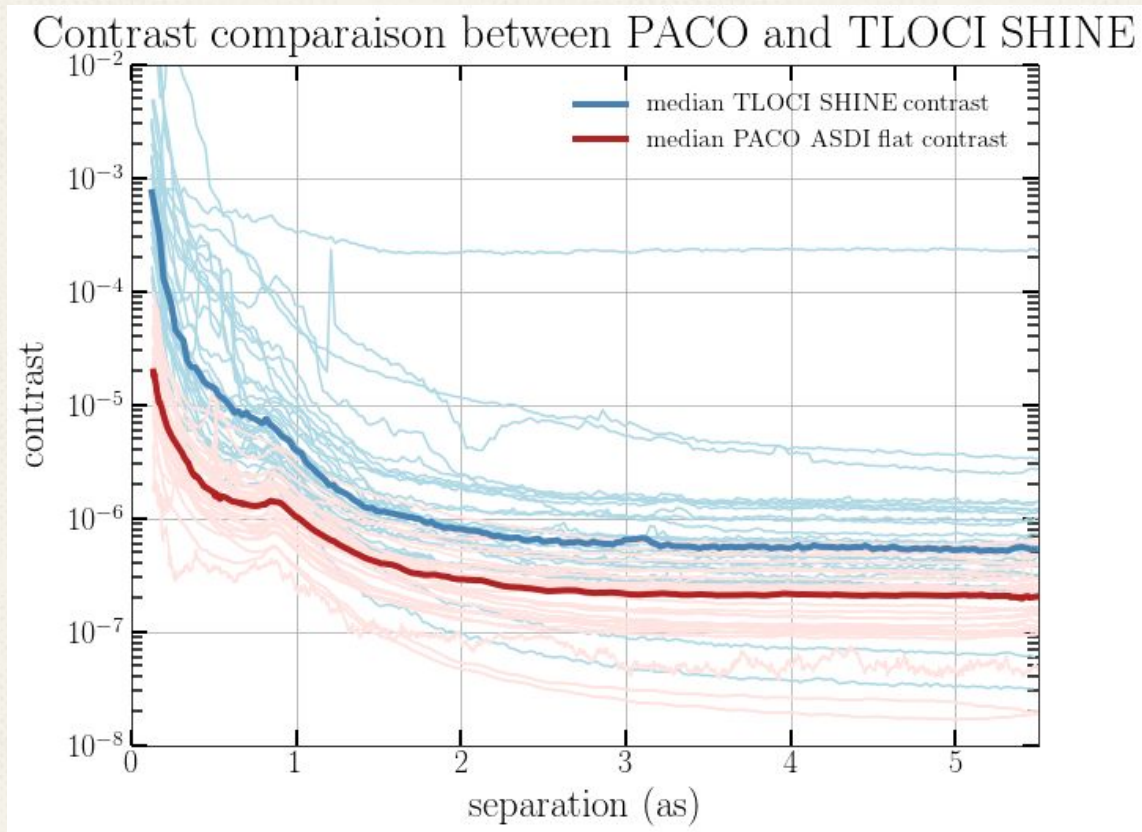




## Forthcoming work

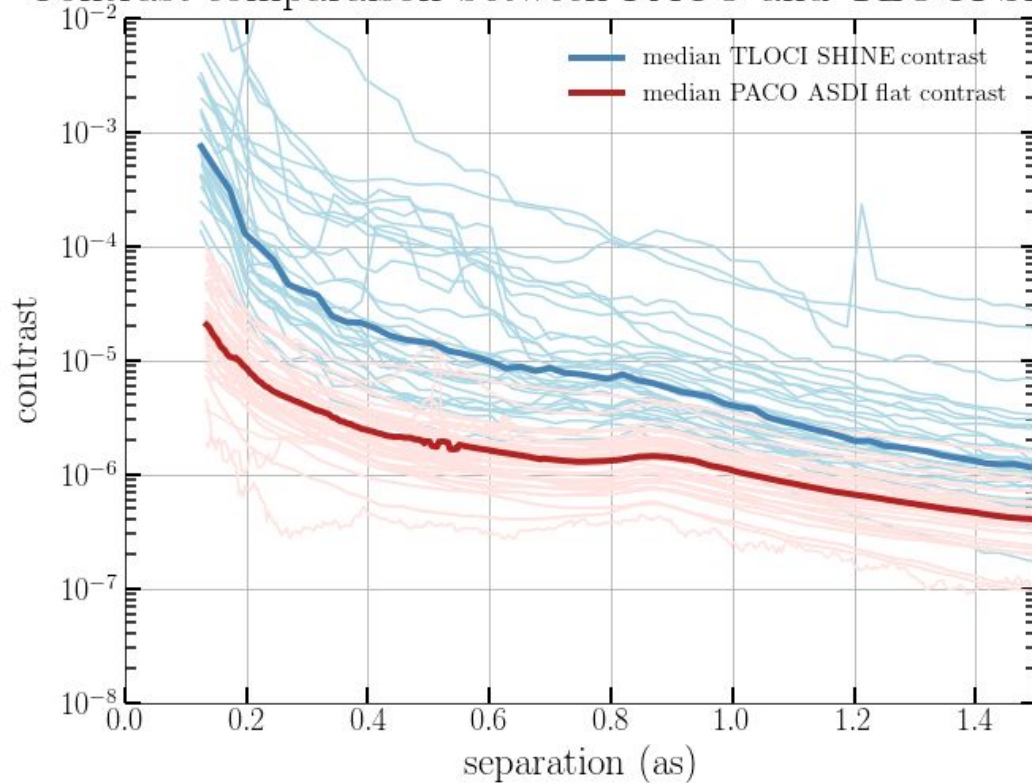
- PACO is the baseline algorithm to perform the F400 analysis
  - Re-analysis of the F150 IRDIS has begun
- The whole SPHERE archive

## BACKUP SLIDE : contrast



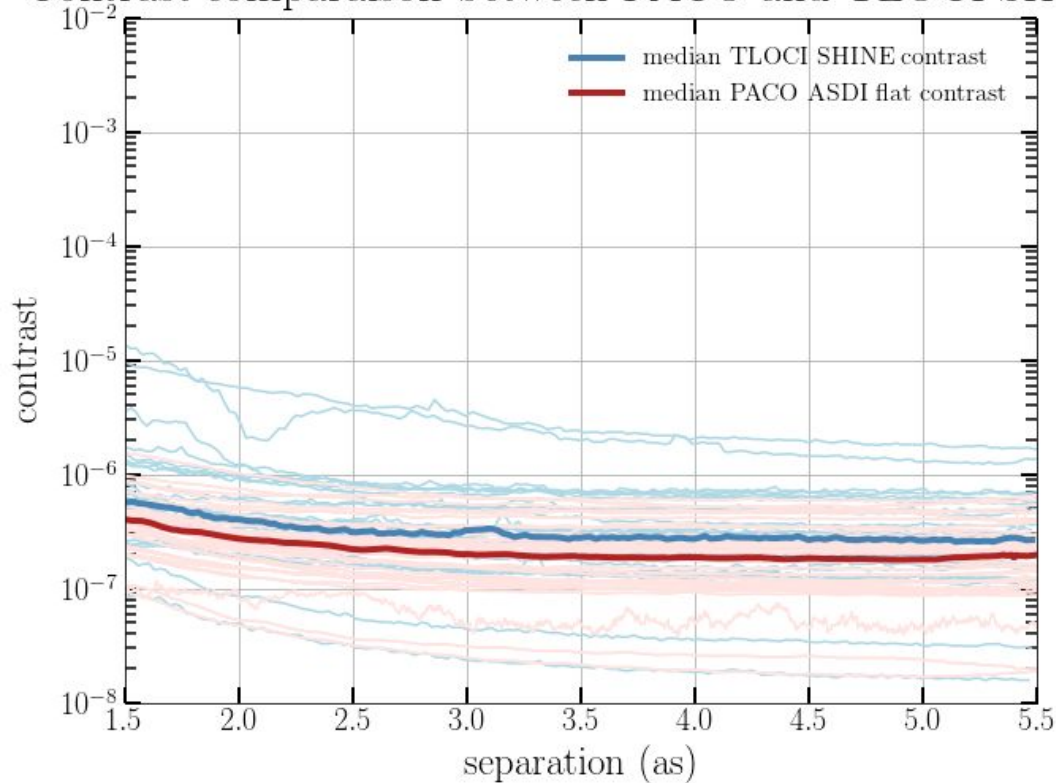
## BACKUP SLIDE : contrast

Contrast comparison between PACO and TLOCI SHINE



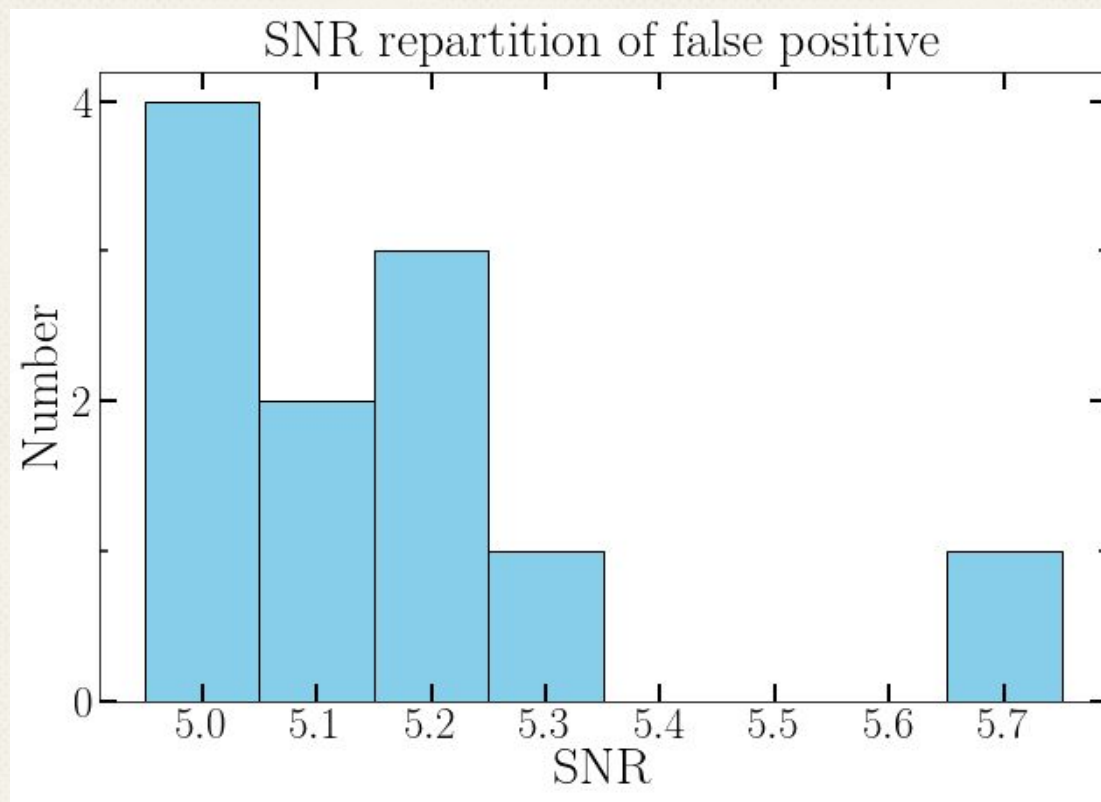
## BACKUP SLIDE : contrast

Contrast comparison between PACO and TLOCI SHINE





## SNR of false positive



# Contrast : All priors

