SHARK-VIS

Science Cases Overview

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& the SHARK-VIS Science Team

THE SHARK-VIS SCIENCE TEAM

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76 people - 15 affiliations, and growing….

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Scientific Advantage of Visual AO

- **Better science detectors:** CCDs or CMOSs
- **Darker Skies**
- **Strong emission lines (Hα)**
- **Off the Rayleigh-Jeans tail:** Sun-like stars have much greater range of colors in the visual than in the near-IR
- **Higher spatial resolution:** access to the 14 mas regime, @ 550 nm a 8.2m telescope has a spatial resolution that would require a 33m ELT telescope in the K band.

Summary of Science Cases

- **Primary**:
  - ExoPlanets:
    - Accreting planets
    - Reflecting light from giant planets !
  - Disks and Jets around young stars
  - Extragalactic astronomy with XAO (AGN hosts & BH feeding mechanisms, SBF?)
- **Ancillary:**
  - Close Binaries
  - Search for faint objects around bright stars (GC, PSR, etc…)
  - Quantum structure of space-time @ Planck scale
  - Photon Orbital Angular Momentum
  - Lunar Occultation
- **Post-baseline: IFU** (already presented by S. Desidera)

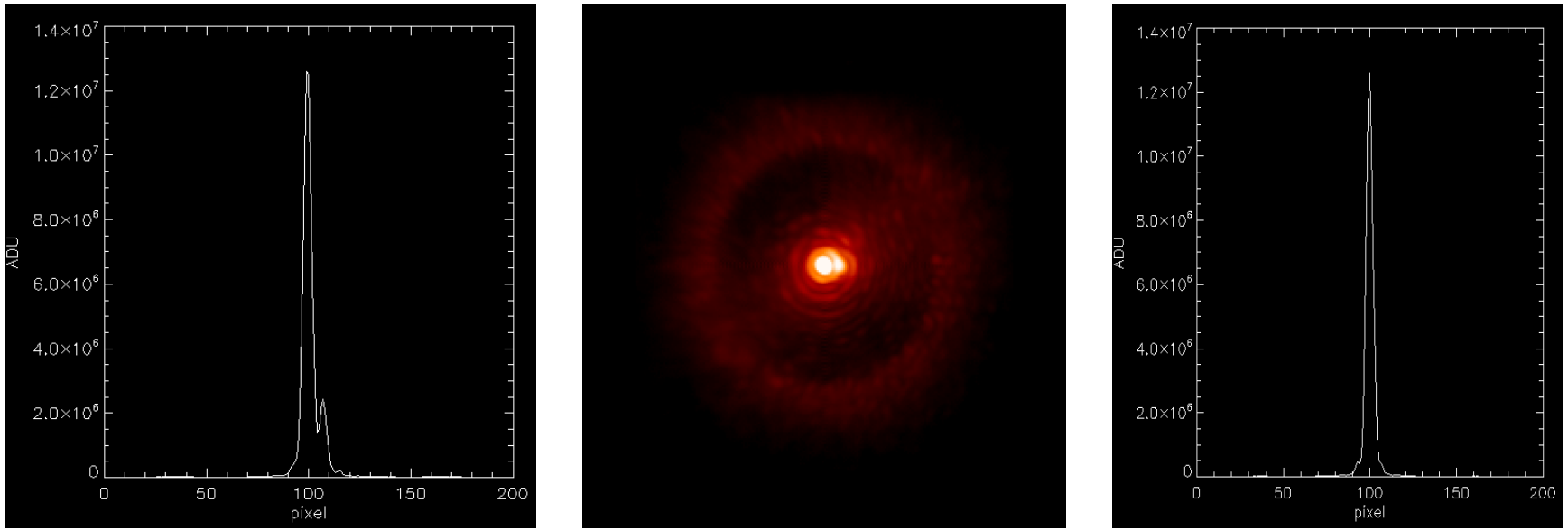
Close binaries

- Goal: visual separation of components, possibly investigating the presence of a third fainter companion.
- Already selected 10+ targets for commissioning and SV

#	ID	Period [d]	Vmag	Sp1 [km/s]	Sp2 [km/s]	K1	K2	Ecc.	Asini [mas]	D [pc]
HIP	76006	581.84	6.40	F6III		13.61	17.70	0.6554	16.91	74.8
HIP	67756	120.027	7.98	F8		22.59	29.17	0.6086	16.92	26.8
HIP	23453	972.162	3.75	K4Ib	B6V	24.60	31.40	0.4100	18.94	241.0
HIP	11070	1815.3	7.15	K2III		11.37	12.31	0.5030	21.04	162.3
HIP	85333	1170	6.05	A0	G	19.50	27.00	0.4500	21.84	204.5
HIP	17732	277.89	6.27	G0		18.70	23.60	0.1430	22.28	48.0
HIP	79358	2200.77	5.63	K3III		15.51	15.69	0.6797	22.36	207.0
HIP	96683	434.169	4.66	G8III-IV	G8III-IV	27.45	28.41	0.5420	22.95	81.6
HIP	42871	713	6.54	F7V		11.60	12.70	0.3500	22.99	64.9
HIP	677	96.7005	2.17	A0p		27.74	65.47	0.5348	23.54	29.7

Close binaries

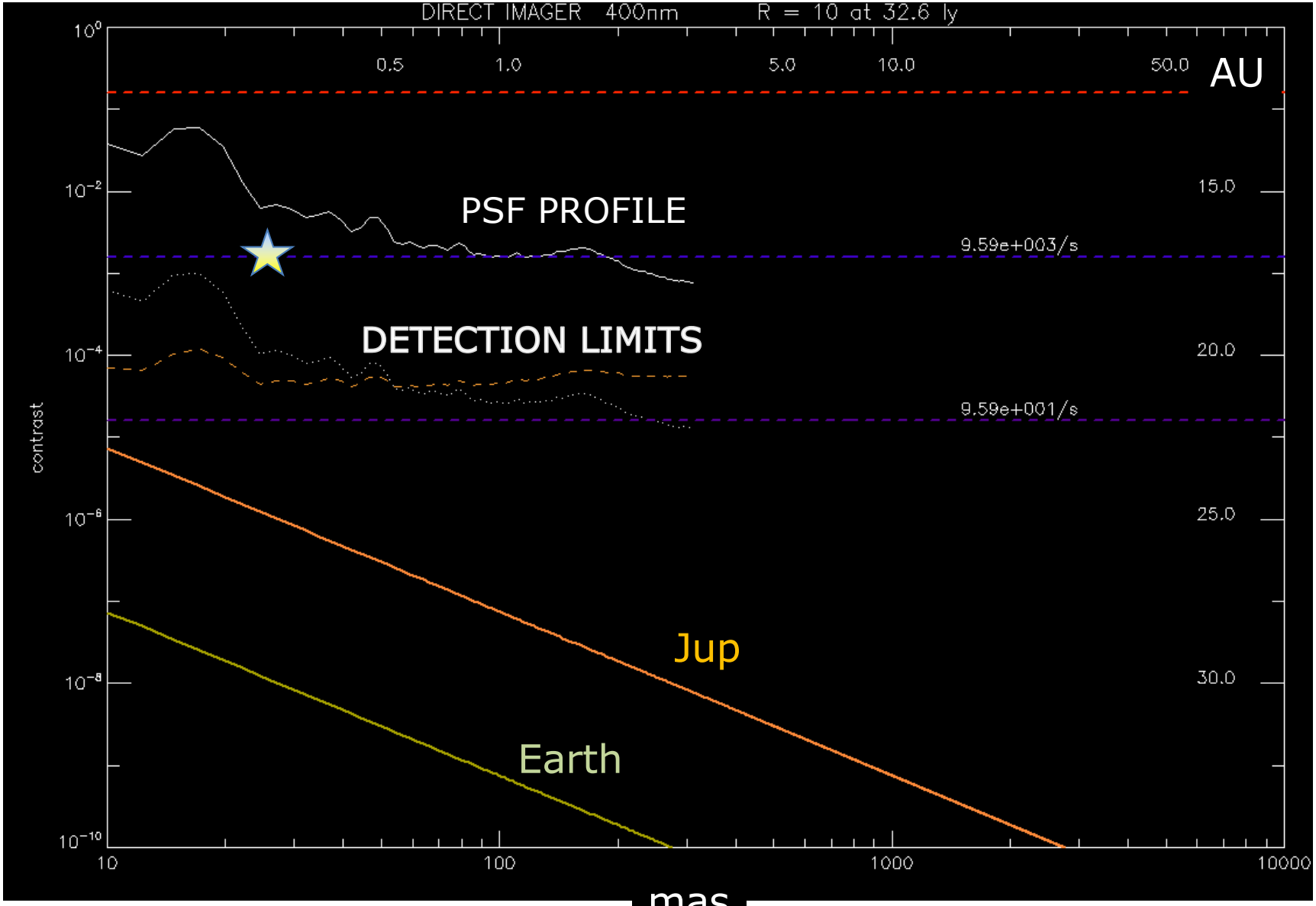
- Test target is HIP 677, simulation below at 25 mas separation without post-processing



HIP 677 convolved with real LBT on-sky PSF @ 630 nm (forerunner experiment)

Contrast and detection plot @400 nm

HIP 677 -DIRECT IMAGING

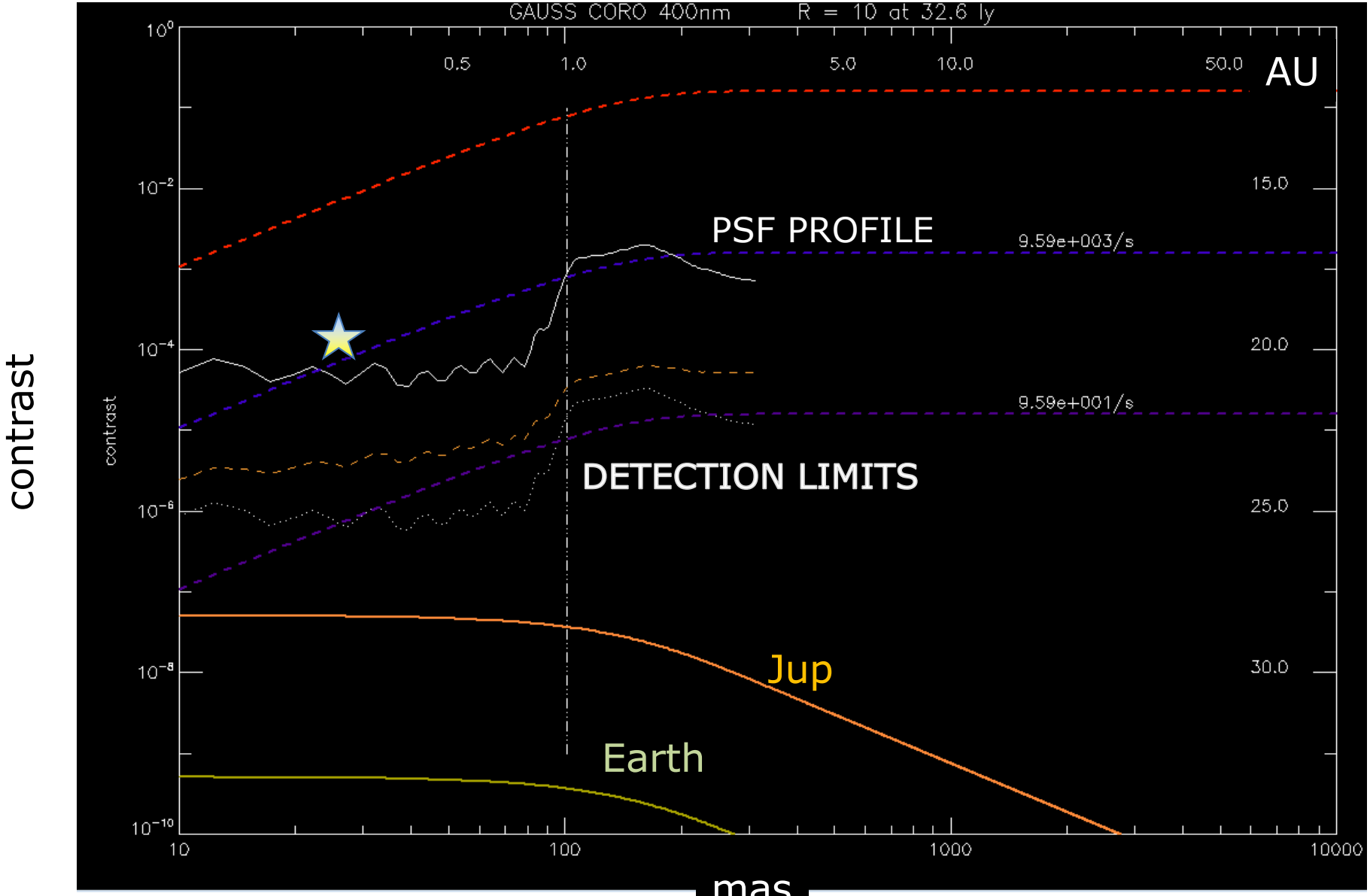


contrast

magnitude

Contrast and detection plot @400 nm

HIP 677 – GAUSS CORONOGRAPHY



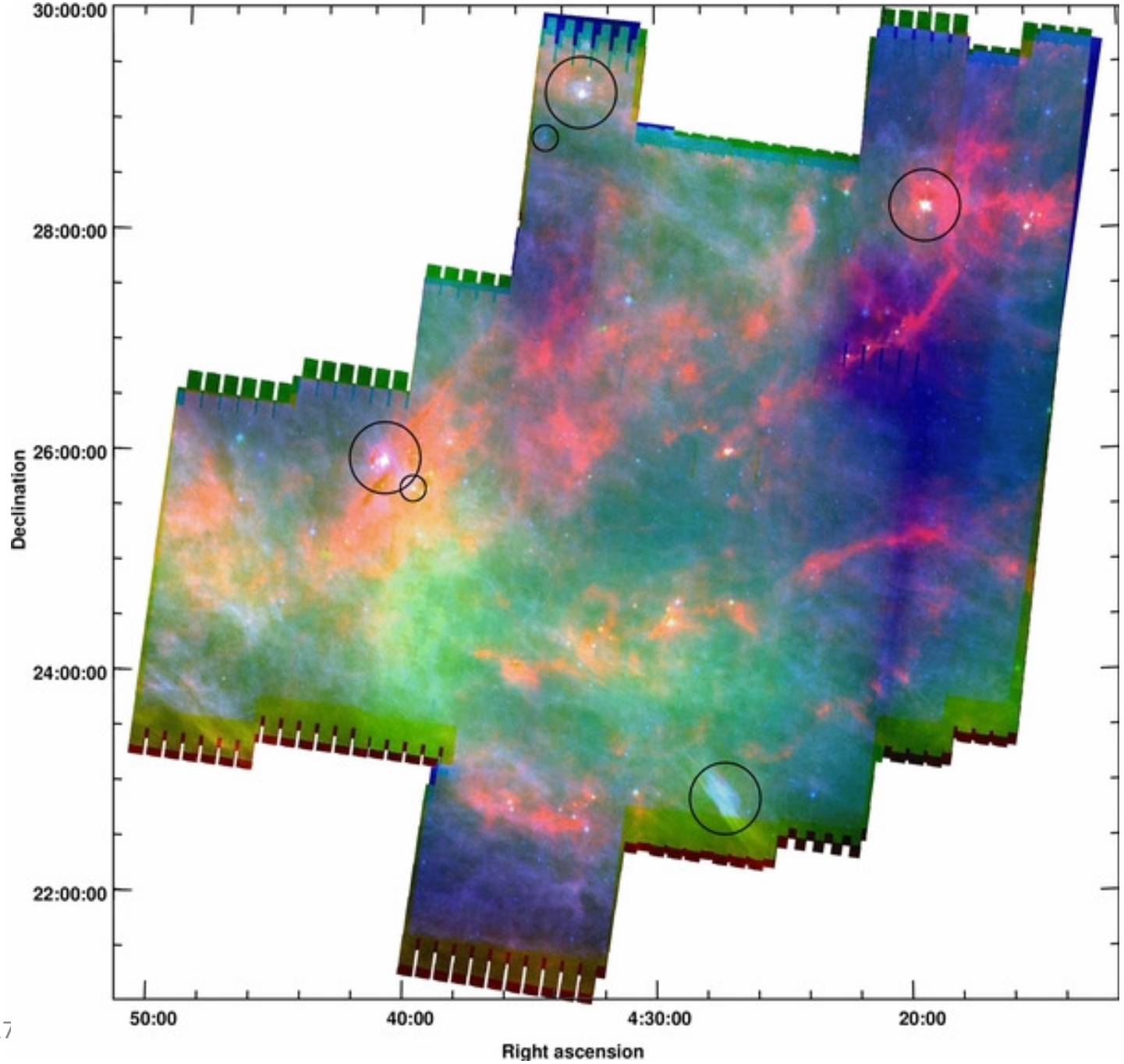
Exoplanets

- The atmosphere of giant planets in external orbits can be probed by direct imaging only
- Up to now ~20+ planets with M > M_{Jup} at distances > 1AU
- Expected increase in the number thanks to SPHERE and GPI (our main competitors)
- LBT AO advantage: high Strehl at faint magnitudes (R~10), even fainter after upgrade to SOUL
- Improvement over competitors allows deep searches in regions relatively distant (i.e.: Taurus-Auriga region @ 140 pc)
- **Young accreting planets: VIS for Hα narrow-band** and simultaneously (SHARK-NIR) for thermal emission
- **Giant planets in reflected light in the visual at small separations (100+ mas)**

Accreting planets

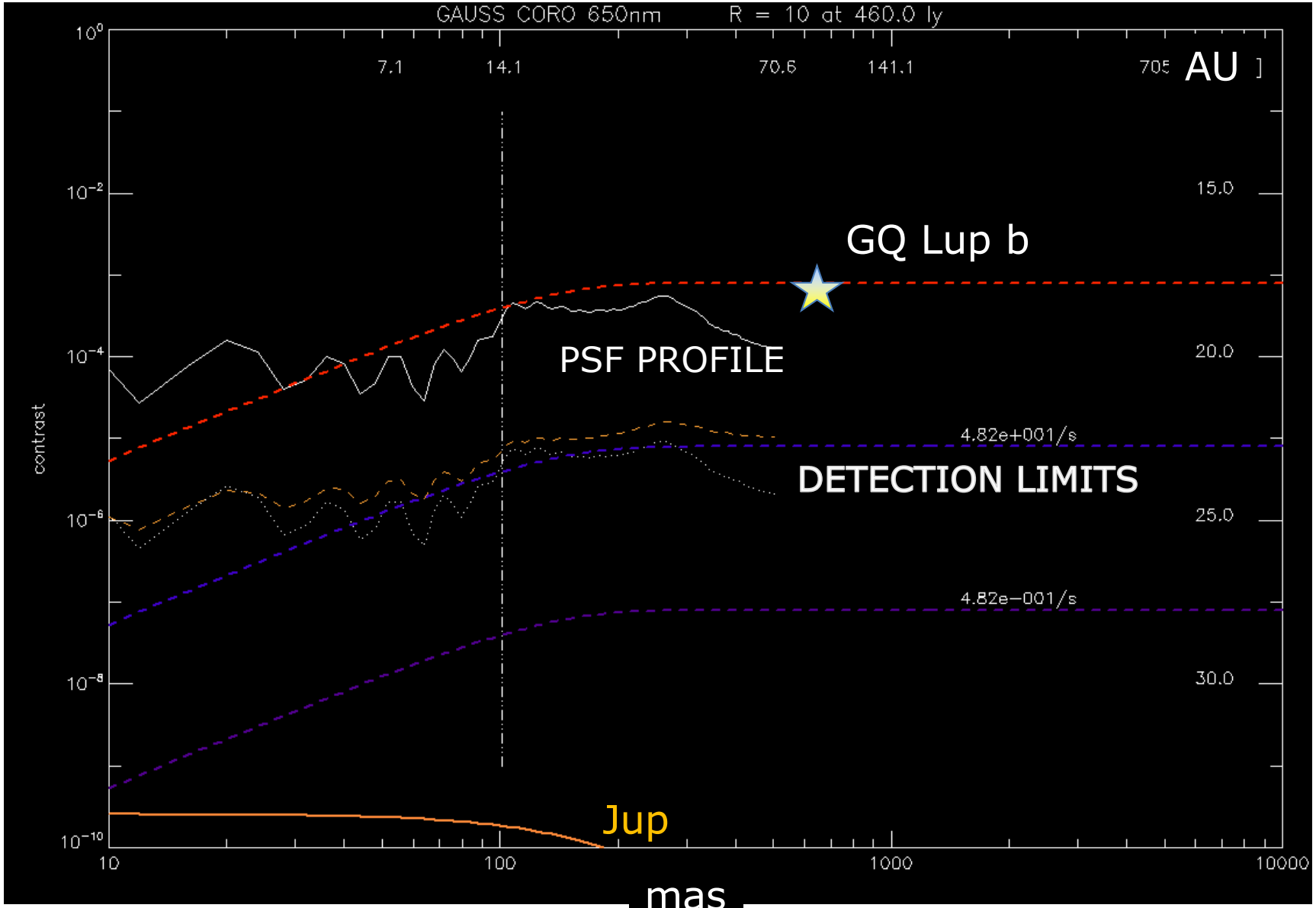
- Rationale is to study accretion disk of young planets to obtain clues of formation mechanisms, duration, accretion rate.
- **Hα emission allows estimates of accretion rate (Close et al. 2014).**
- **Contrast at Hα is also much more favorable than at other wavelenghts, as confirmed by HST observations (Zhou et al. 2014)**
- **LBT+SHARK-VIS allows access to northern sky and to faint magnitudes, both unreachable with SPHERE and GPI**
- Good target sample in the Taurus-Auriga star-forming region @ ~140 pc
- 30+ targets selected for commissioning and SV with R<11

Taurus-Auriga Star Forming Region



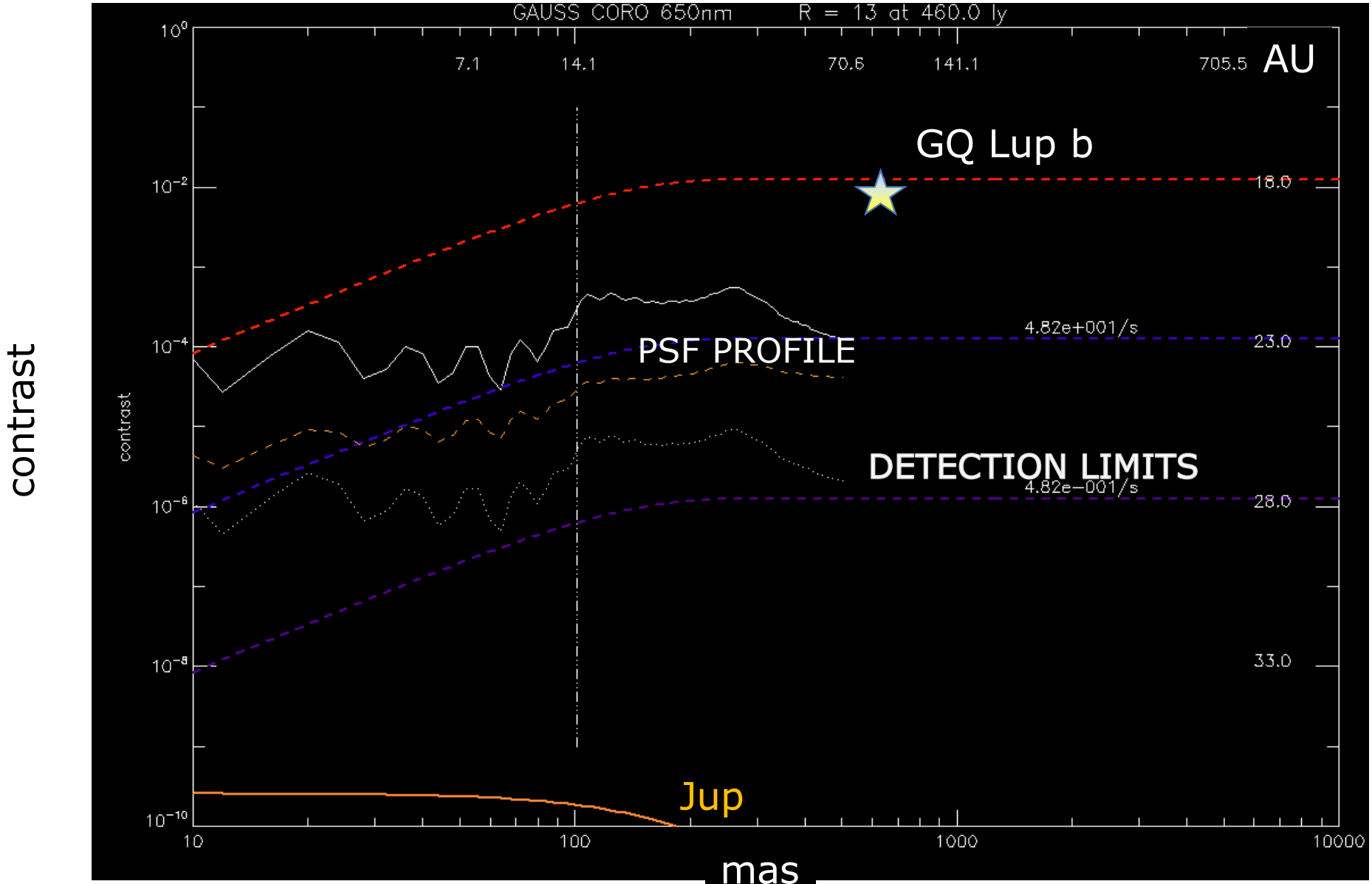
Contrast and detection plot @650nm WIDE

Tau Aur – GAUSS CORONOGRAPHY



Contrast and detection plot @ Halpha

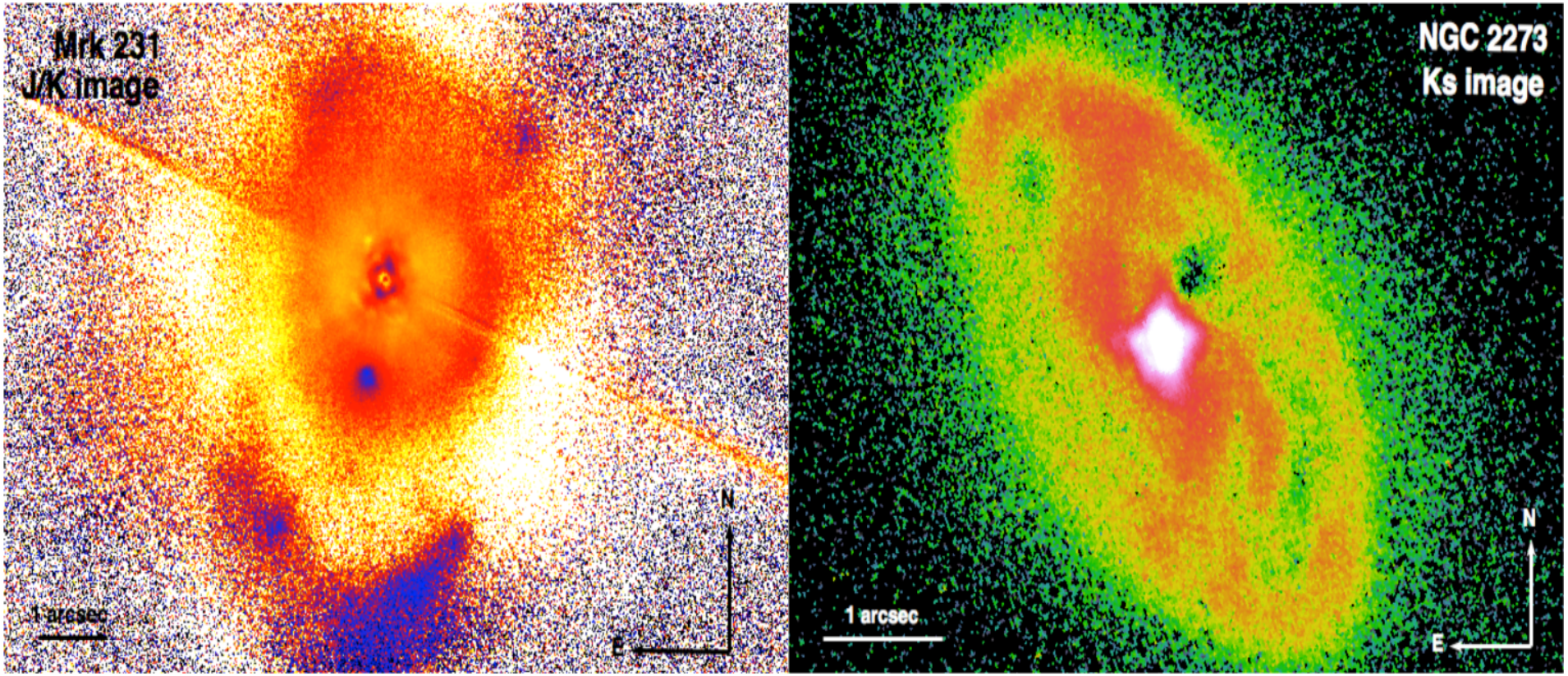
Tau Aur – GAUSS CORONOGRAPHY



AGN and BH feeding mechanisms

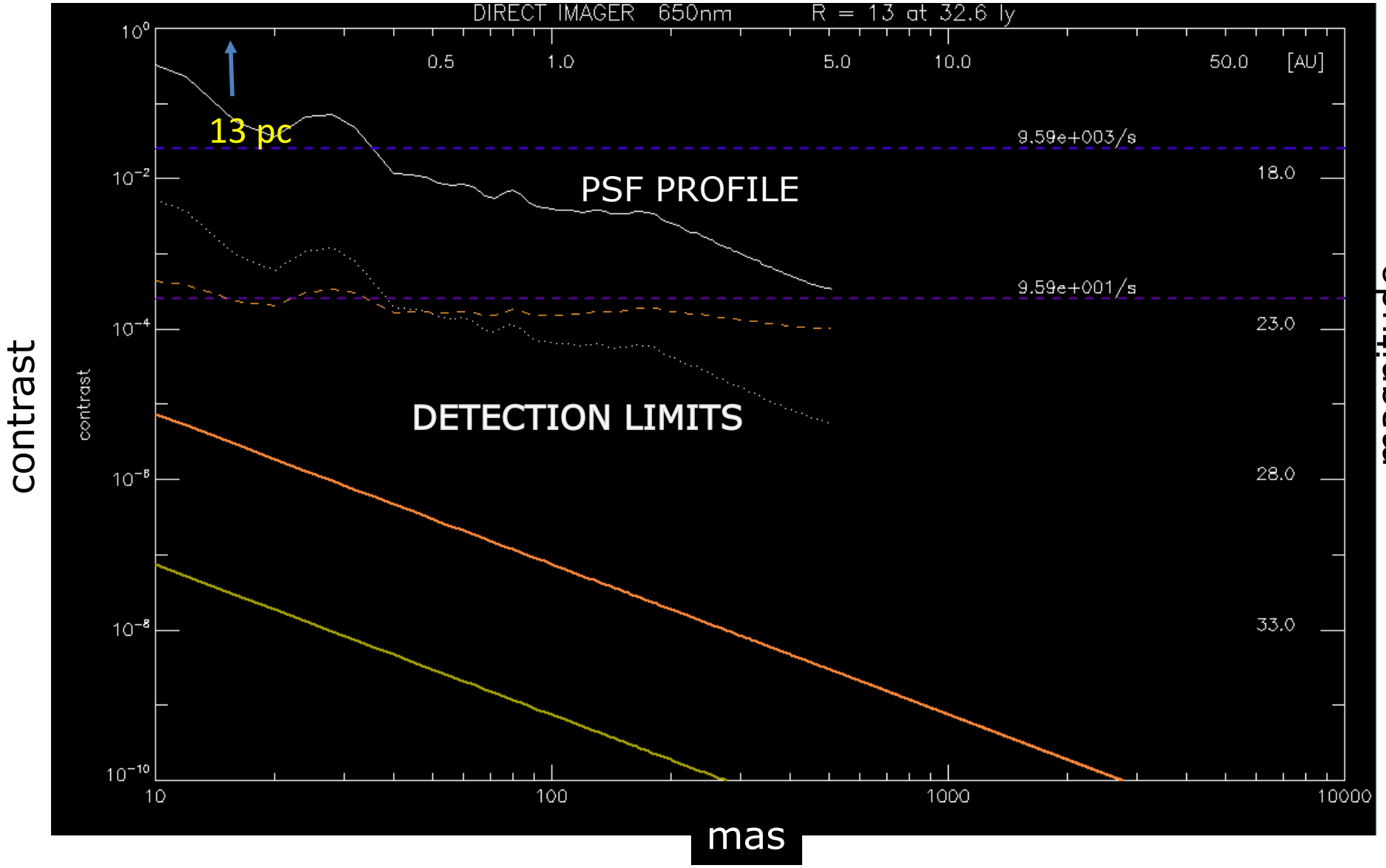
- In the extragalactic field SHARK-VIS can give a unique contribution to the study of feeding/feedback mechanism in nearby sources, AGN-host relations and Damped Ly-α Systems (DLAs).
- SHARK offers the unique opportunity for a breakthrough in these fields, thanks to:
  - improved resolution with respect to present NIR instrumentation
  - **pushing AO correction in the optical band to achieve a resolution a factor of three better than HST**
  - **integral field spectroscopy in the optical band,**
  - LMIRCAM synergy in imaging and coronography.

AGN and BH feeding mechanisms



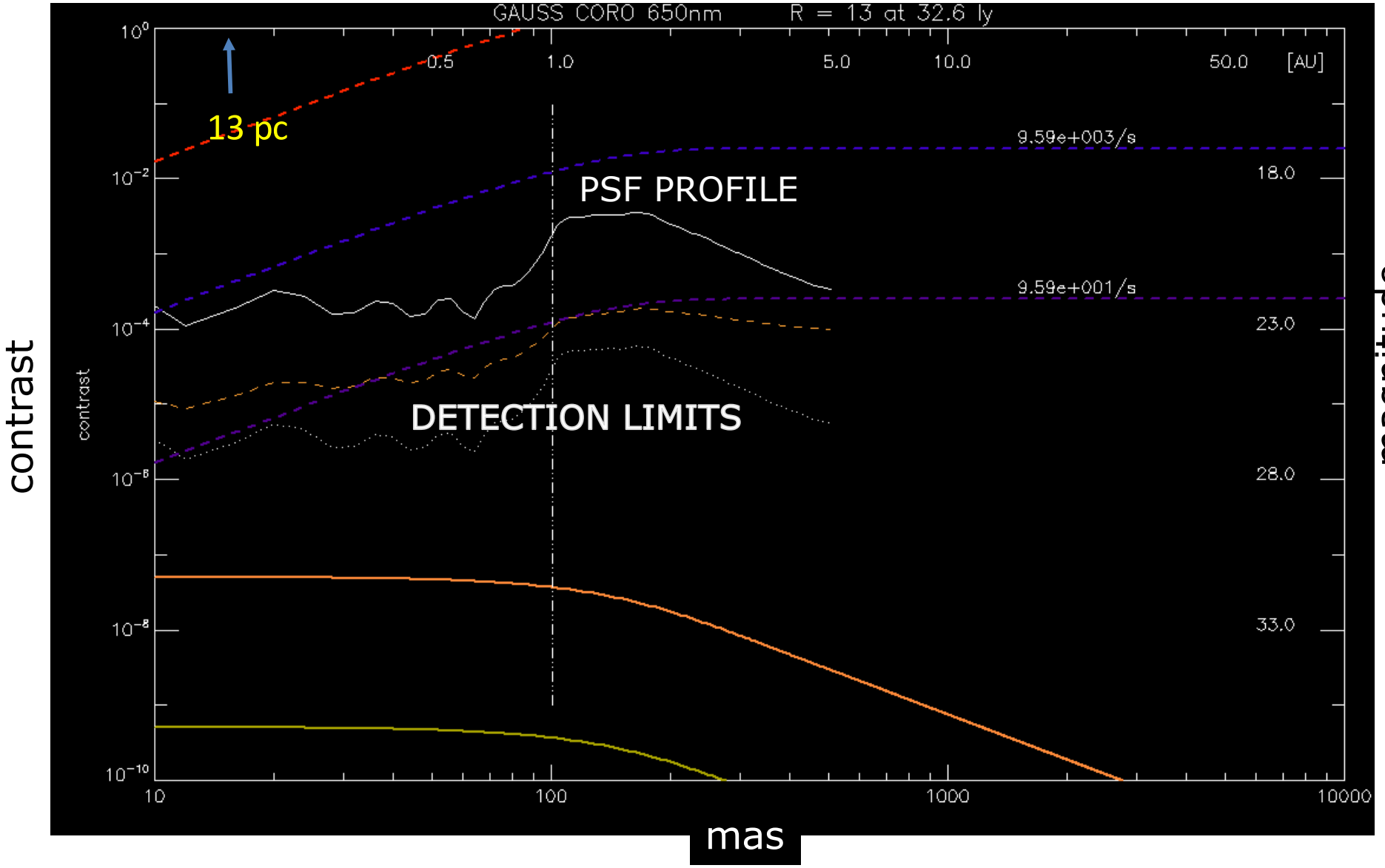
Contrast and detection plot @ 650 nm

Mrk 231 – DIRECT IMAGING



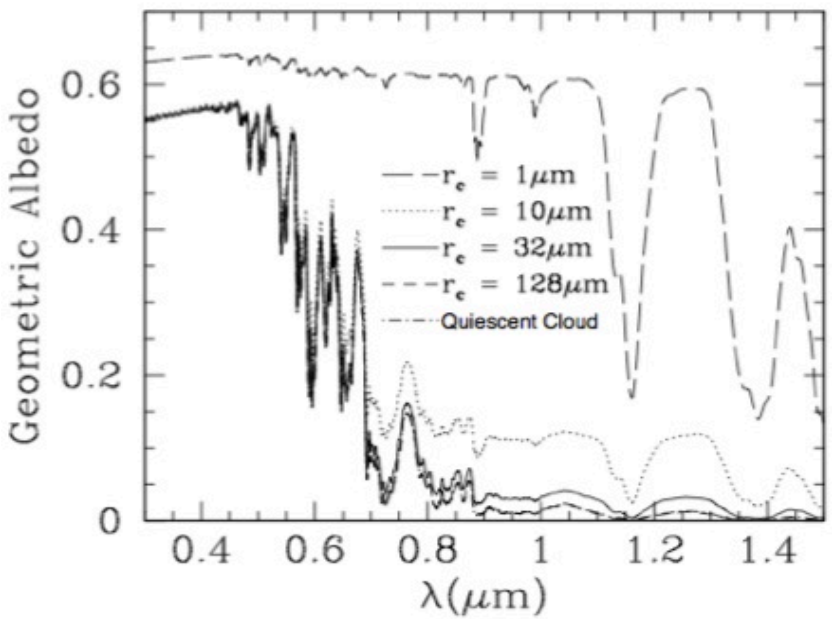
Contrast and detection plot @ 650 nm

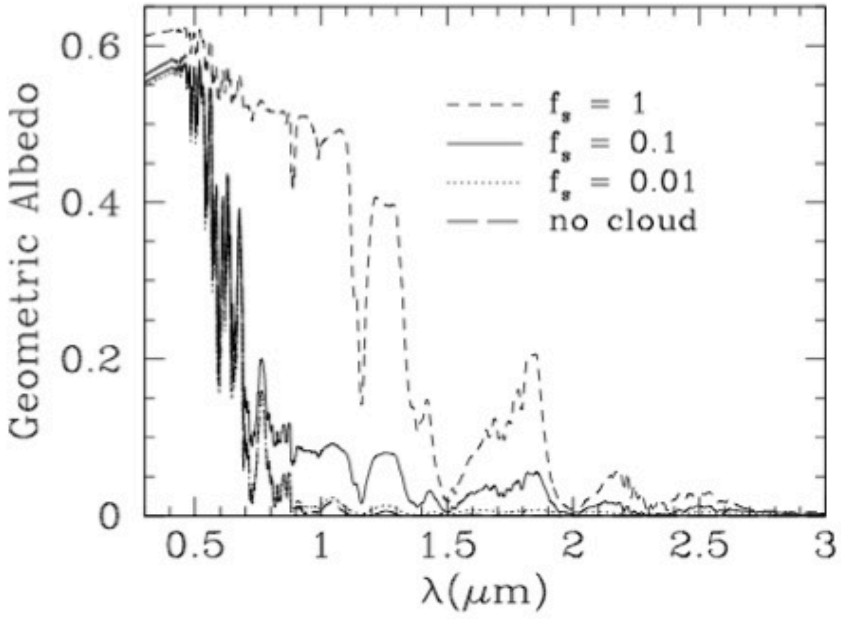
Mrk 231 – GAUSS CORONAGRAPHY



Reflected light from giant planets

- Goal is to study high-albedo giant planets close to their stars using the irradiated light
- NIR useful for thermal contribution @ ~300K
- **Visual imaging and IFU for albedo spectral properties**
- Search for water vapour clouds
- Range of masses 0.5-4 M_J, around A-G stars, at 1-3 AU and within 10 pc

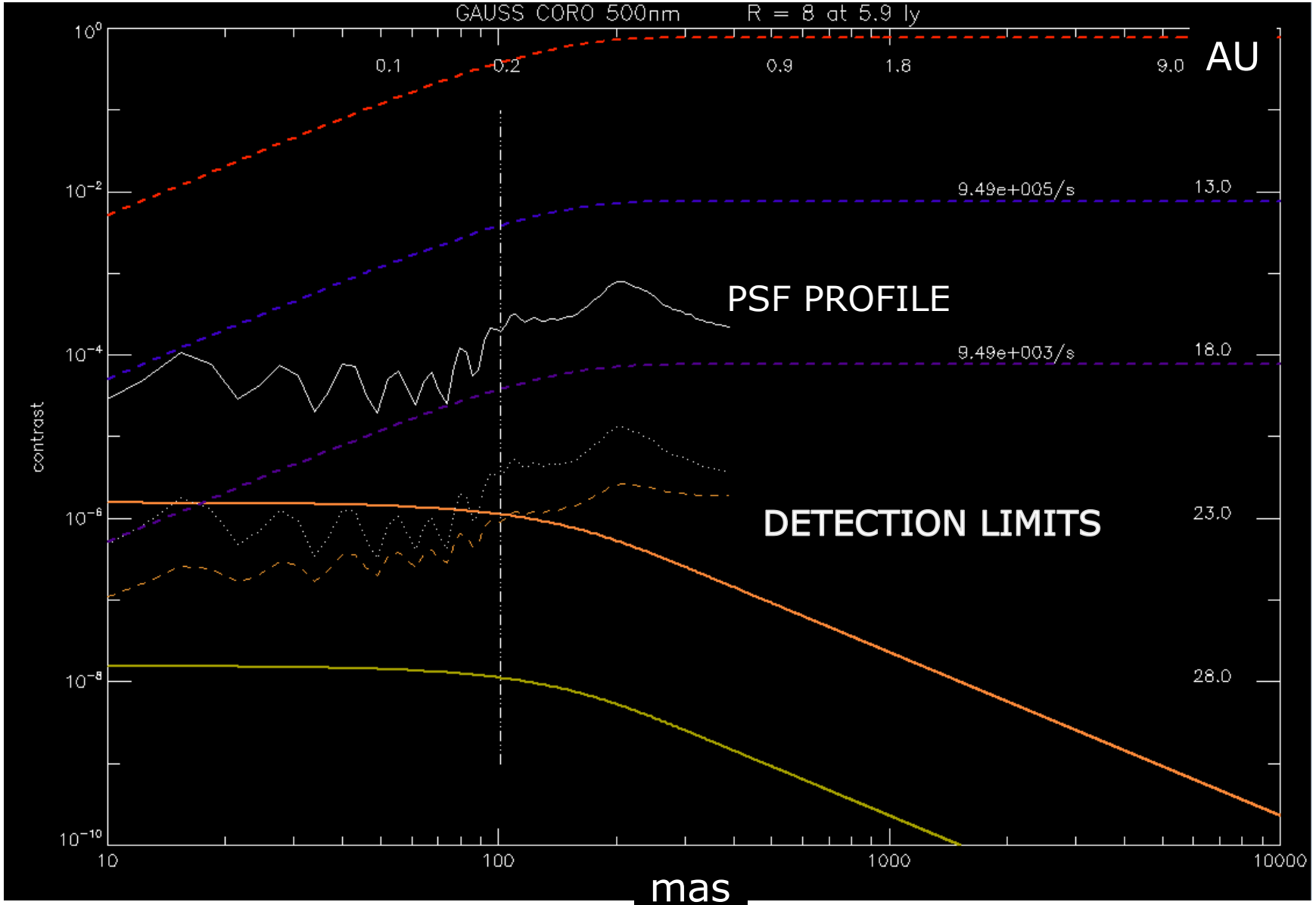




Marley et al. 99

Contrast and detection plot @ V_{WIDE}

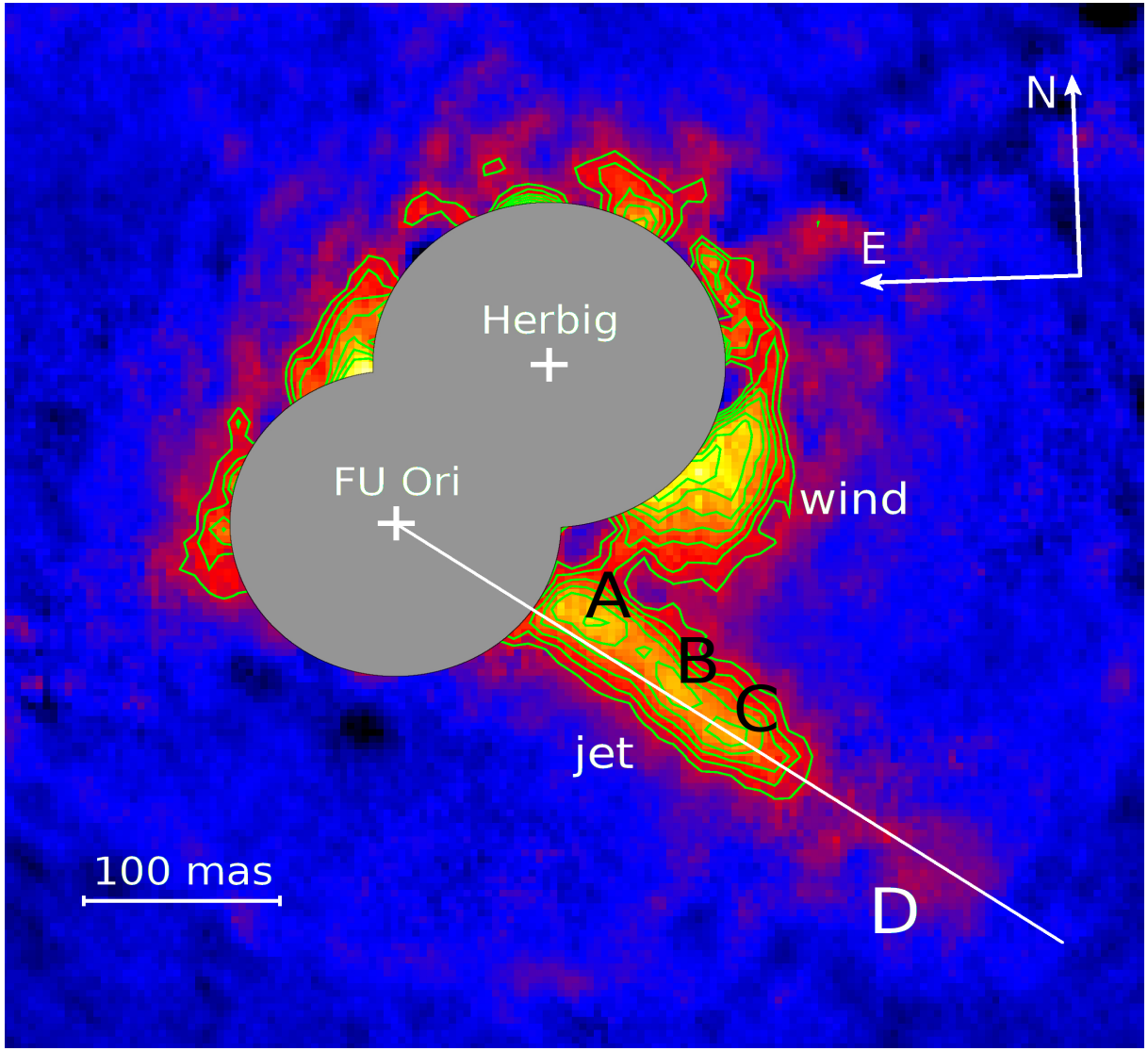
Barnard's Star – GAUSS CORONOGRAPHY



Disks and Jets around Young Stars

- Goal is to study the interplay between accreting disks and jets from parent stars at the highest possible resolution. SHARK would allow to obtain:
  - a) **High-contrast images of circumstellar disks with optical/near-IR coronography and polarimetric differential imaging**
  - b) **Imaging of stellar jets** with unprecedented resolution close to the star
  - c) **Jets investigated with the IFU: 2-D maps in velocity intervals and derived spectral diagnostics**
- Great benefit from synergy with NIR SHARK and also with LMIRCAM

ZCmA @ 630 nm (OI)



Post-baseline: IFU

- Much interest around the possibility of installing an IFU at SHARK-VIS.
- Sub-field with field de-rotation, 200spaxel, in a 20x10 arrangement with 0.2x0.1 arcsec^2 coverage.
- Several science cases discussed before will benefit of an IFU:
  - Detecting reflected light from giant planets, spectral properties of the atmosphere
  - Jets in young stars
- Combination of high-contrast imaging and high-dispersion spectroscopy to characterize planet atmosphere, using coronagraphy and R=75000 IFU
- Thanks to the high-contrast foreseen for SHARK-VIS, systems with contrast 10^{-6} at 200 mas can be observed, e.g. ε Eri b
- The planned spectral coverage will allow us to cover the oxygen A-band at 0.7 micron, which is a very critical diagnostics for chemical composition analysis of the planetary atmospheres.

Summary

- Visible AO coronagraphy promising
- Commissioning and SV targets (primary science cases):
  - 10+ close binaries
  - 30+ Tau Aur young accreting planets (10+ also suitable for jets)
  - 2+ extragalactic targets
  - 10+ stars closer than 5 pc
- ~40-45 targets with ~3 hr/targets -> 150 hr open shutter
- At 6 hr/night this translates in two years of operation (if meteo friendly…)
- Big interest from colleagues
- Lots of “meat” for the BBQ
- B.Y.O.”M.”
- Extend participation to other LBT partners (suggestion by LBT director @ CDR)

THANK YOU!

…and an indecent proposal:

SHARK-VIS + PEPSI ?.....