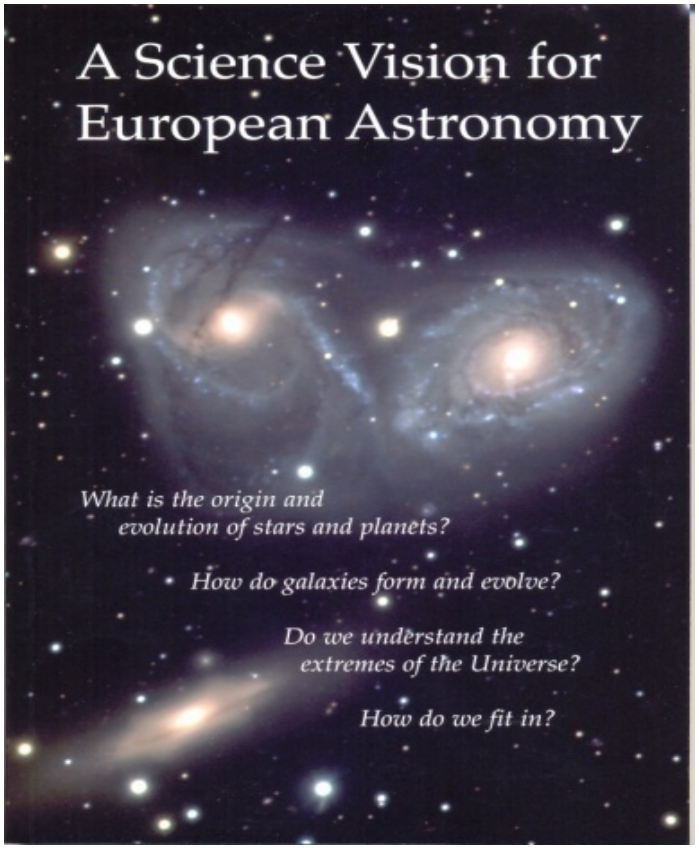
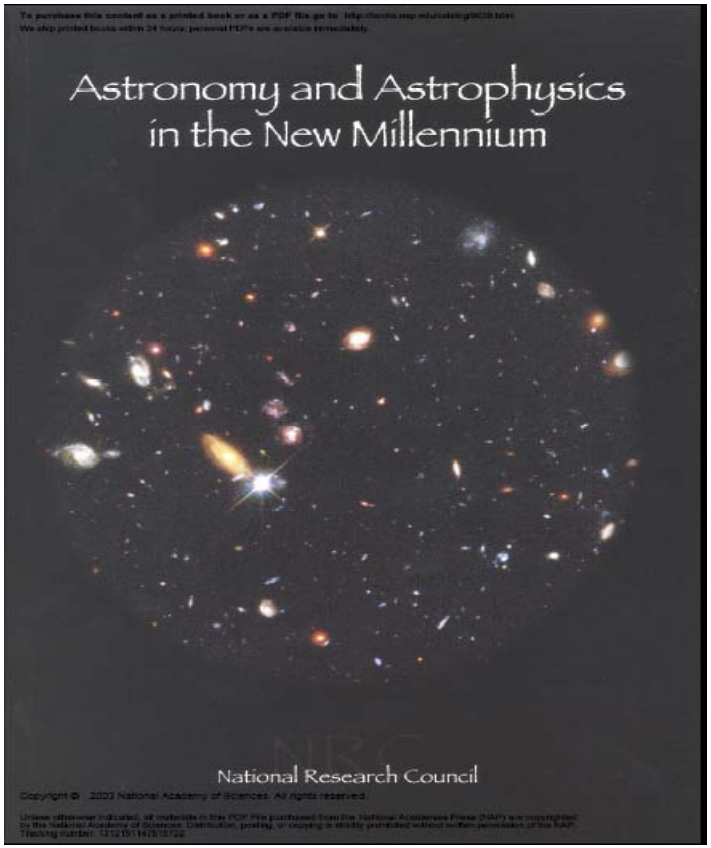
The Mid-infrared on ELT's

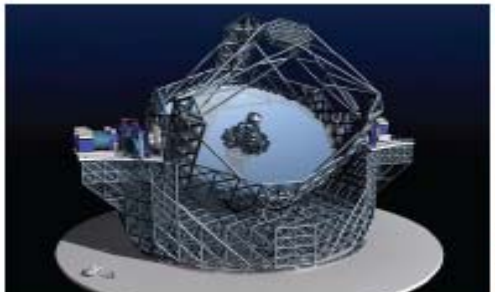
(3 - 25μm)

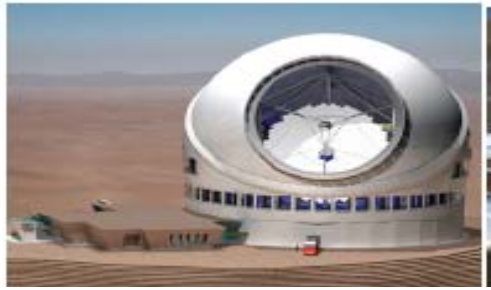




MIR recommended to be essential

Future ELT-class





	METIS	MIRES	MIISE
Facility	ELT (42m)	TMT (30 m)	GMT (24.5m)
Imaging FOV	18”	15”	40"
wavelength [μm]	3 - 14	5 - 25	3 ~ 25
LR N	R~300		R~1,500
MR N	R~3000		
HR N	R~50,000	R~60,000–120,000	

Present MIR instruments: <8m

Sub-8-meter-class




INSTRUMENT		BLINC-MIRAC4	MIRSI	MIRLIN	SPECTROCAM-10
Facility		MMT (6.5 m)	IRTF (3.0 m)	Palomar Observatory (5.08 m)	Palomar Observatory (5.08 m)
MODES	Imaging FOV	11.5" to 44" square	85" x 64"	20" square	15" square
	LR N		R~200		R~100
	MR N				R~2000
	HR N				
	Other	Nulling interferometry	LR Q (R~100)		
SENSITIVITY [mJy] 10σ, 1h obs. time	N imaging		30		
	Q imaging		300		
	LR N		375		
	MR N				
	HR N				

Present MIR instruments: ≥8m

Current 8-meter-class





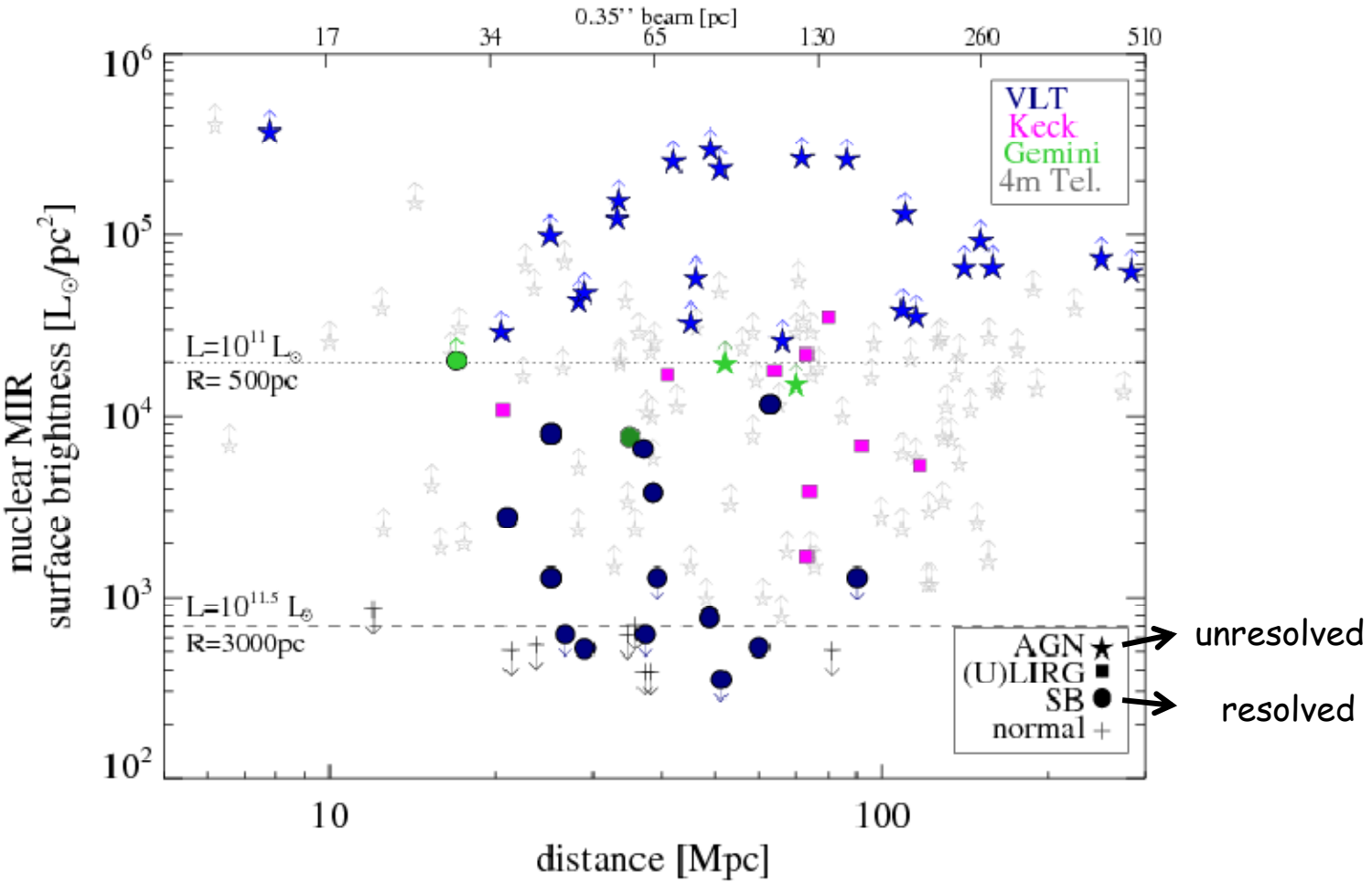


INSTRUMENT		VISIR	MIDI/VLTI	MICHELLE	T-RECS	COMICS	TEXES	CANARICAM
Facility		VLT (8.2 m)	VLT UTs (8.2 m) VLT ATs (1.8 m)	Gemini North (8.1 m)	Gemini South (8.1 m)	Subaru (8.3 m)	Gemini (8.1 m)	Gran Telescopio Canarias (10.4 m segmented)
MODES	Imaging FOV	19.2" or 32.3" square	1-2"	32" x 24"	21" x 28"	42" x 32"		18" x 26"
	LR N	R~350		R~200	R~100	R~250		R~175
	MR N	R~3200		R~1000–3000	R~1000	R~2500		R~1300
	HR N	R~25,000		R~10,000–30,000		R~8500		
	Other		Interferometry	LR Q (R~110), N polarimetry	LR Q (R~80)	MR Q (R~2500), HR Q (R~5300)	HR (R~100,000)	LR Q (R~120), MR Q (R~890), dual-beam N polarimetry, coronagraphy
SENSITIVITY [mJy] 10σ, 1h obs. time	N imaging	4	>1000	9	4	8		4
	Q imaging	50		36	60	110		
	LR N	50	>3000	60	80	630		
	MR N	300		210				
	HR N	6000		1200			906	

Sensitivity = BLIP x Site x Telescope

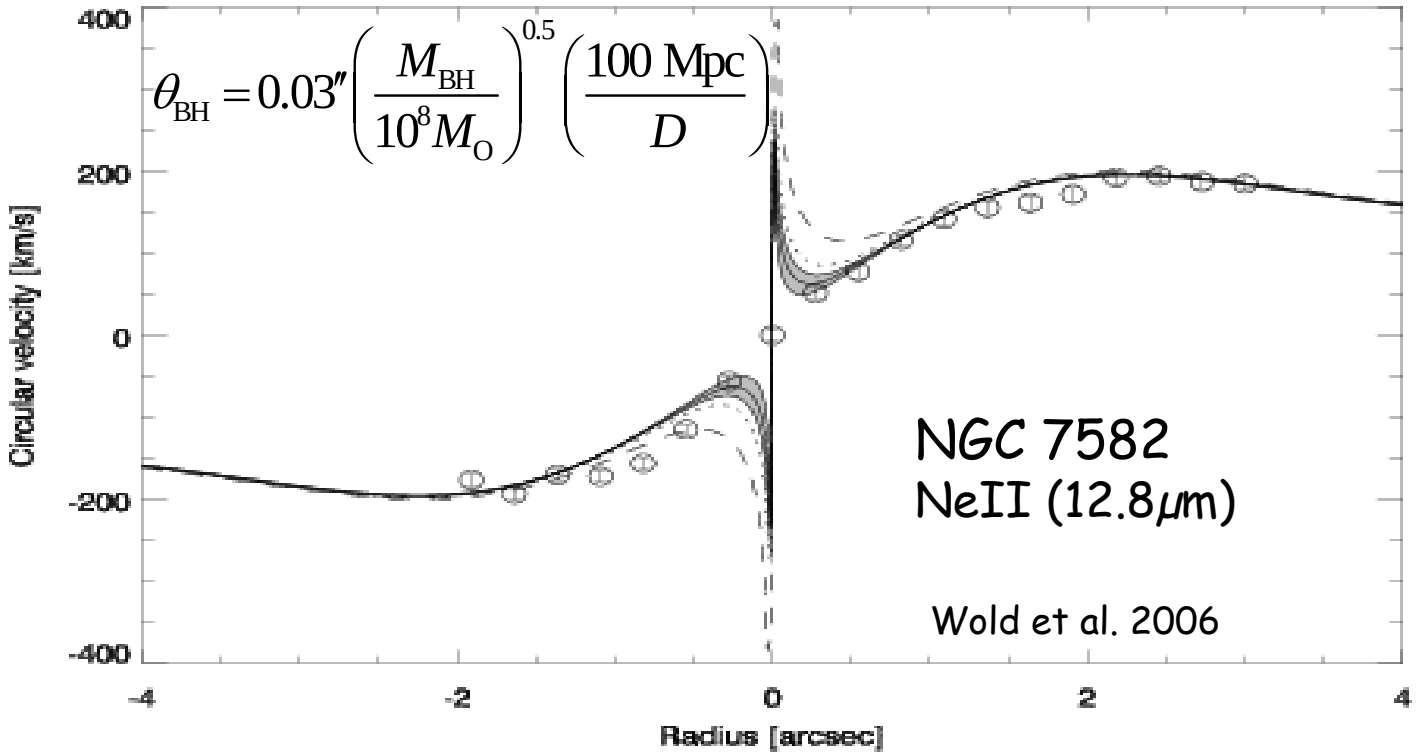
A taste of spatial resolution
4m viz 8m

AGN★ viz starburst●



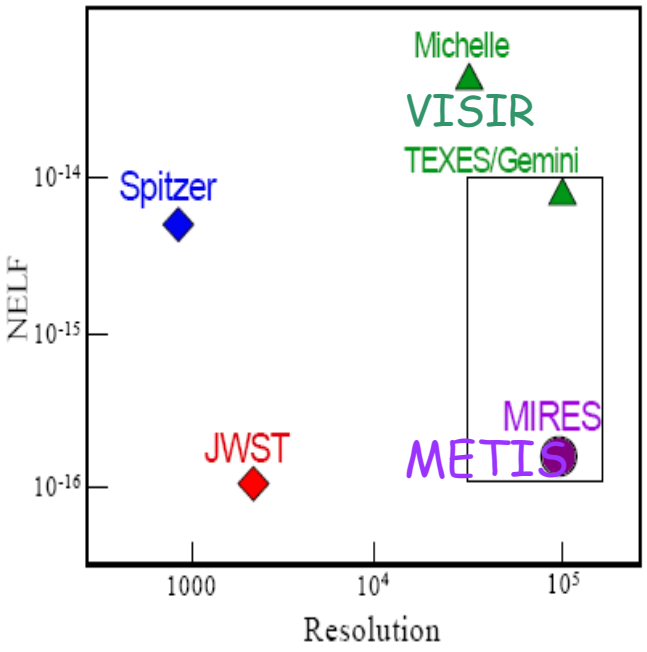
HR spectroscopy: velocity field

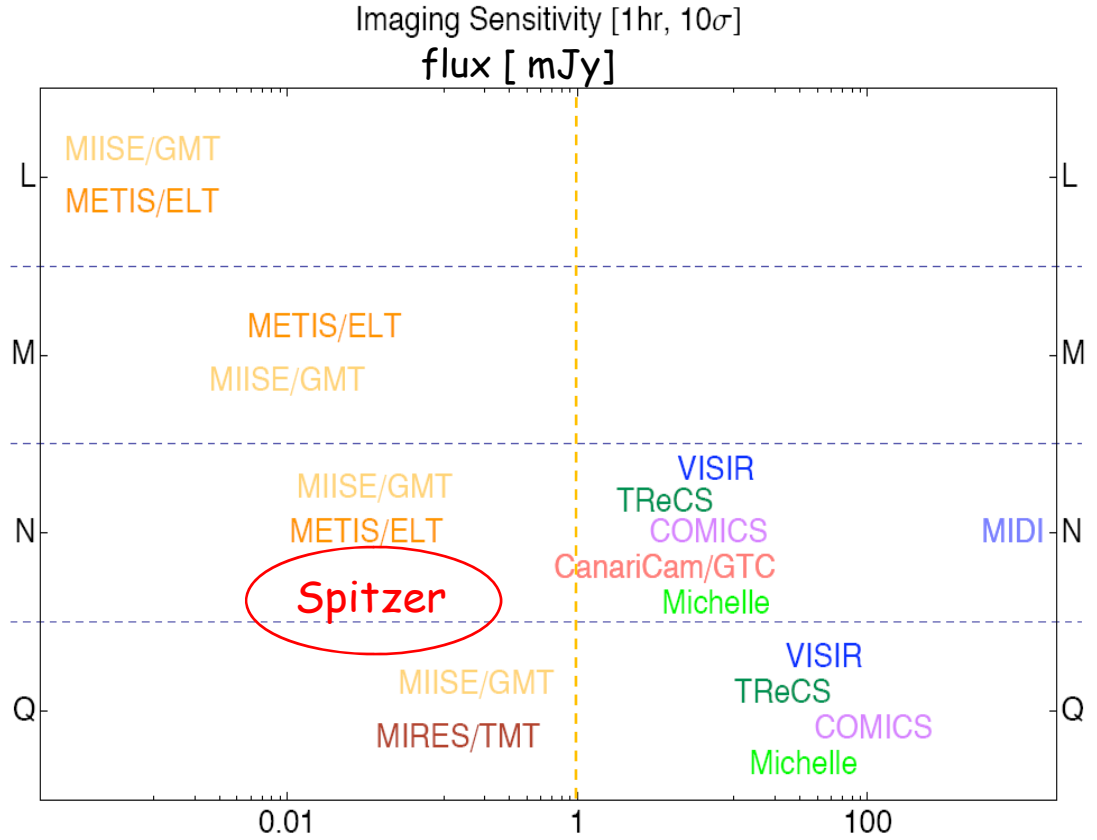
Keplerian gas motion-> black hole mass



VLT,JWST, ... - ≤ 10m - unresolved

ELT - > 30m - resolved





Space & Airborne

INSTRUMENT	IRAC	IRS	MIPS	EXES	FORCAST	MIRI
Facility	Spitzer Space Telescope (0.85 m)	Spitzer Space Telescope (0.85 m)	Spitzer Space Telescope (0.85 m)	SOFIA (2.7 m)	SOFIA (2.7 m)	James Webb Space Tel. (6.5 m segmented)
Imaging FOV	5.12' square		5.4' square		8.2' square	79" x 113"
MODES: LR N		R~60–120		R~2000		
MR N				R~10,000		
HR N		R~600		R~100,000		
Other		LR N (R~60–120), LR Q (R~600)		range extends beyond N; same R		IFU, coronagraphy

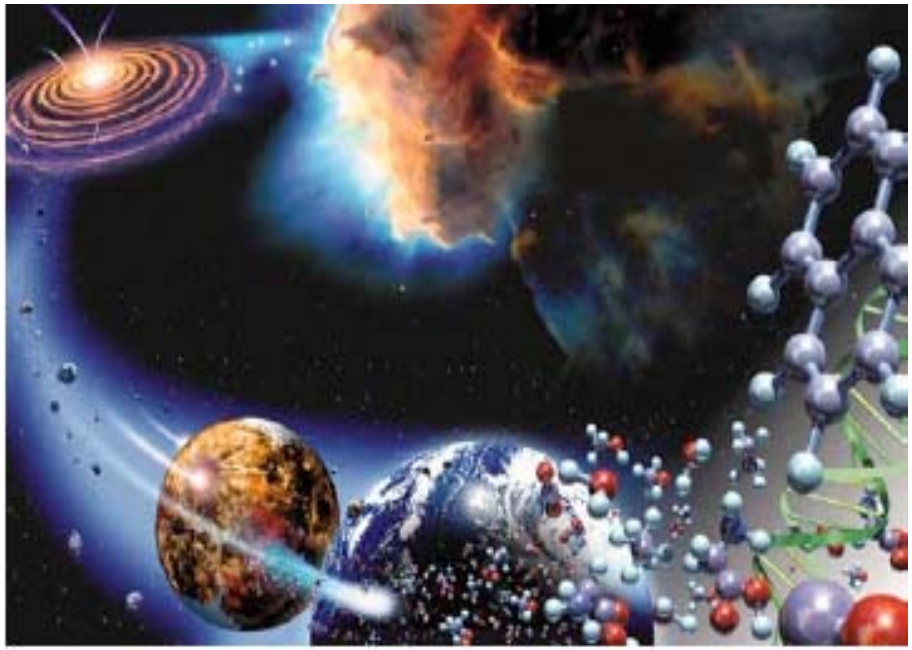
MIR/ELT `galactic' science cases

- Life cycle of dust
- Star formation
- Governing disk architecture for planet formation
- Dynamical history of the solar system
-....

MIR/ELT will solve host of astronomical questions by resolved spectroscopy and imaging

Evolution of proto-planetary & debris **disks**

Formation of **stars** in MC



Planet formation
Solar system: unique?

Building blocks &
Origin of life

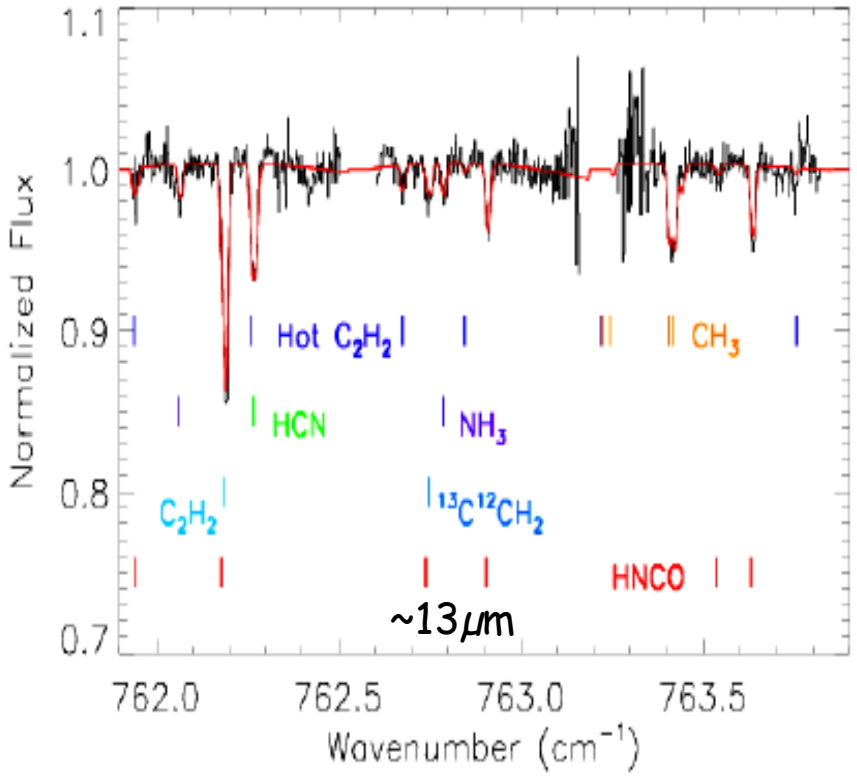
Richness of MIR

Molecules:

+extinction

H_2	
H_2O	water
HDO	
H_2O_2	
OH	
SiO	
OCS	
SO_2	
H_2S	
SiS	
H_2CO	formaldehyde
CH_4	methane
CH_3D	
CH_3	methyl radical
C_2H_2	acetylene
HCN	hydrogen cyanide
HNCO	isocyanic acid
NH_3	ammonia

C_2H_4	ethylene
C_2H_6	
C_4H_2	
C_6H_2	
C_3H_8	
CH_2CCH_2	
C_6H_6	benzene
HCOOH	formic acid
CH_3OH	methanol
HN_2CHO	formamide
HC_3CHO	acetaldehyde
CH_3COOH	acetic acid
$HCOOCH_3$	methyl formate
CH_2OHCHO	glycoaldehyde
C_2H_5OH	ethanol
$(CH_3)_2CO$	acetone
$HOCH_2CH_2OH$	ethylene glycol
NH_2CH_2COOH	glycine

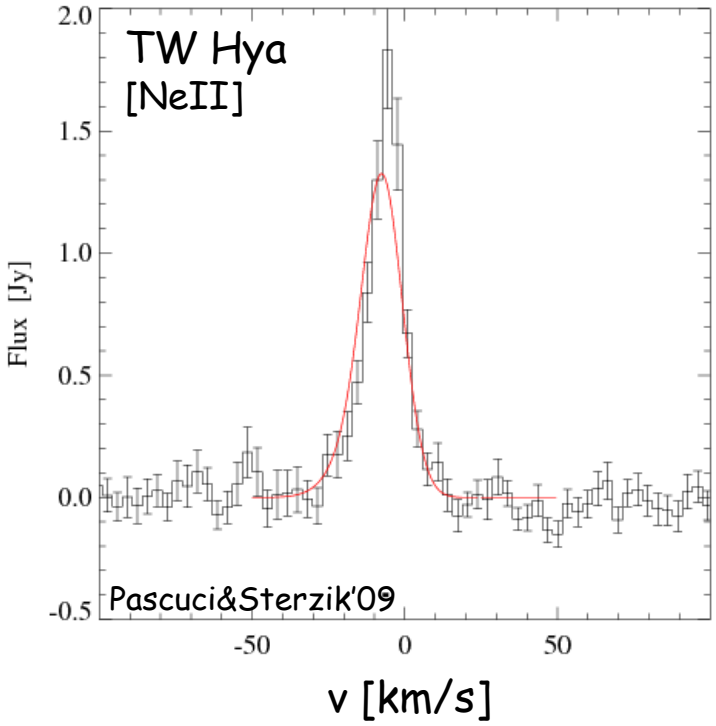


+ solid state
+ PAH
+ atoms
+ ions

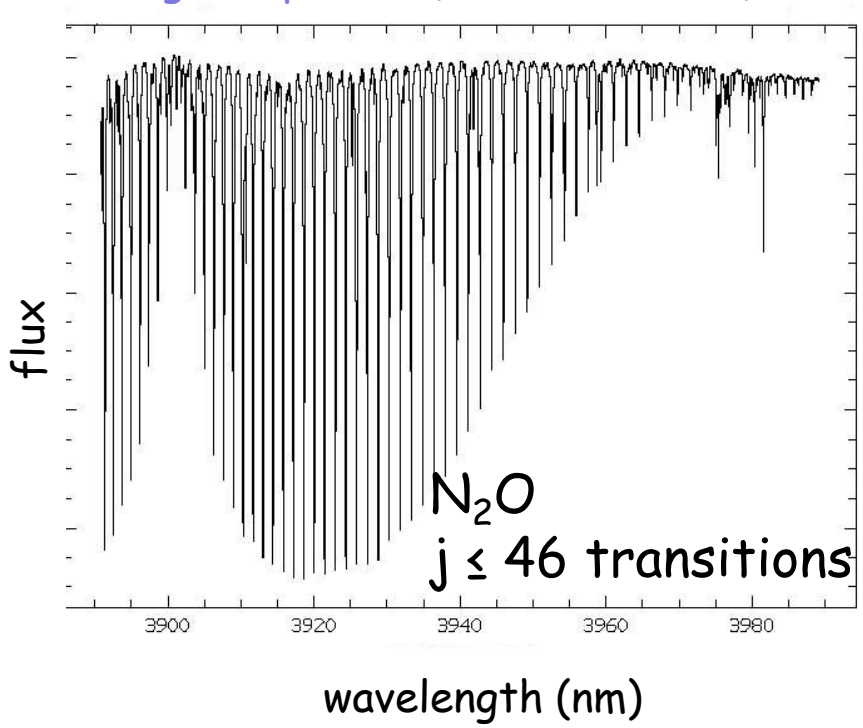
MIR spectroscopy in: ISM, disks, comets

Resolved lines -> velocity information;
density, temperature, abundance

Photoevoparative disk wind



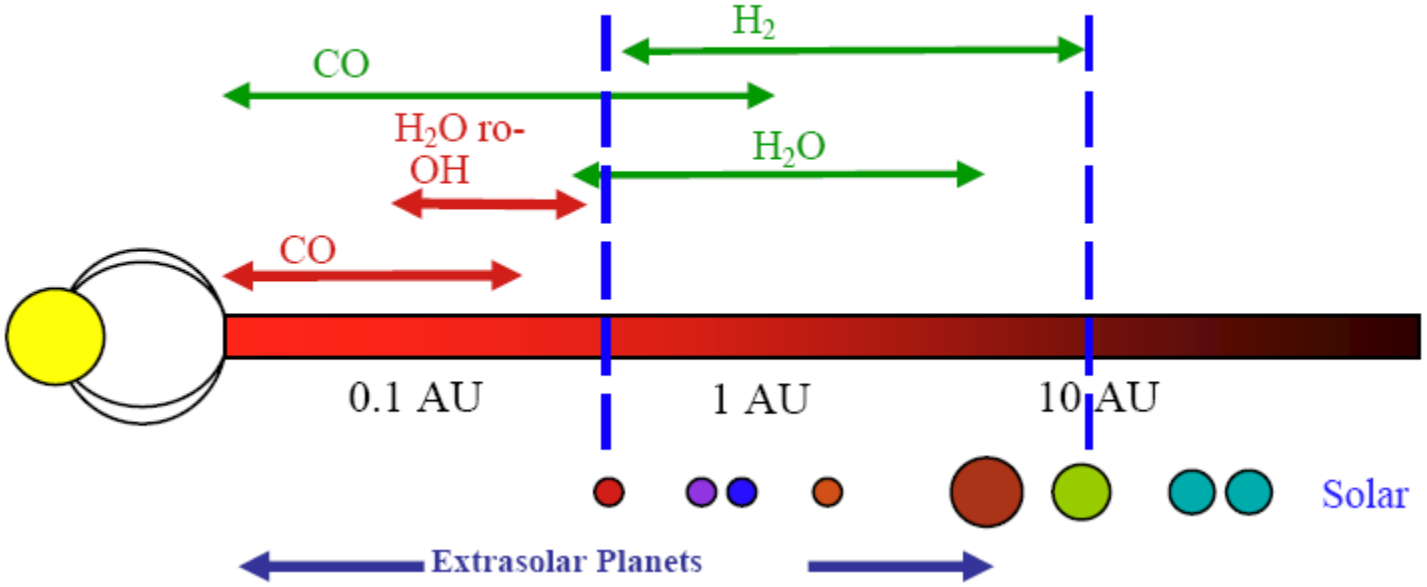
Single exposure (not with ALMA)



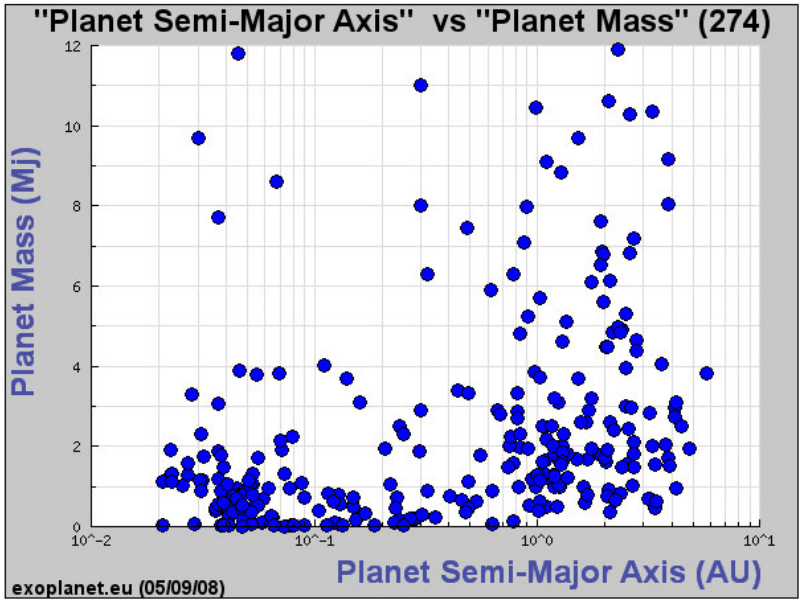
Proto-planetary disks

- chemical structure of the disk
- velocity field and turbulent disk mixing
- probe pathways of planet formation

scale: --- ELT ---> <---- ALMA ---



Exo-planets



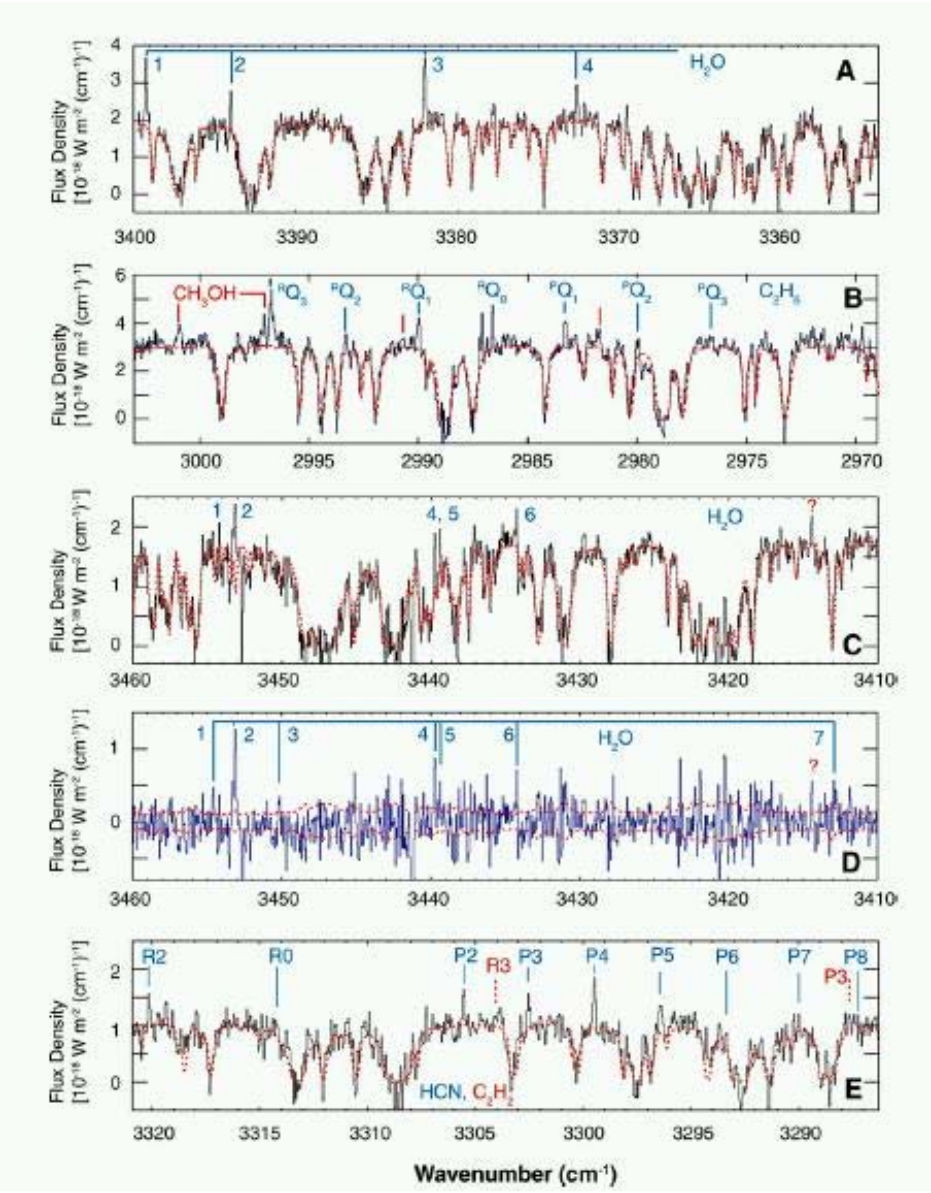
- Ground:
RV studies + scattered light imaging ->
Orbit parameters (M, r, ε)

Transit~> atmosphere

-Space: Kepler, SIM
improved statistics

-ELT/MIR:

Resolving disk structure
Velocity field
Planet thermal emission
Spectroscopy of bio markers



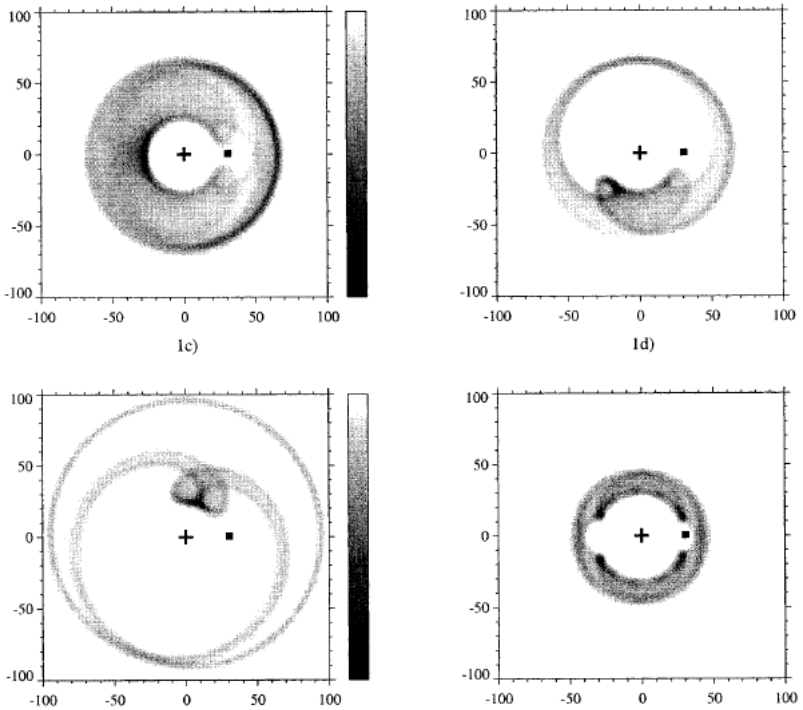
Origin of life ?

In-situ search for prebiotic molecules

Delivery to Earth via heavy bombardment?
->
ELT provide event Statistics of:

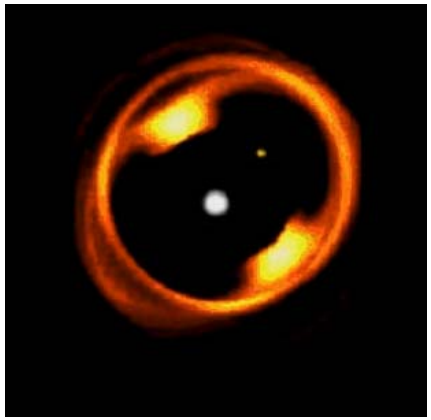
3-5μm: ices in comets (Mumma et al.)

Debris disk structure: theory



Disk + planet: possible dust density
(Ozernoy et al.)

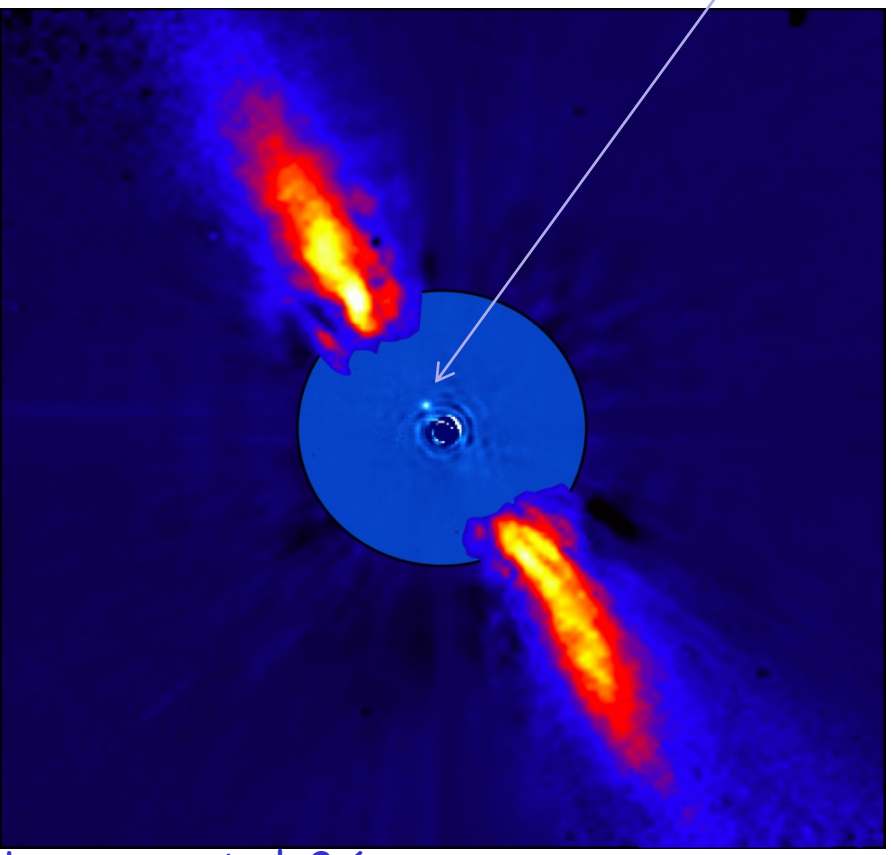
JWST



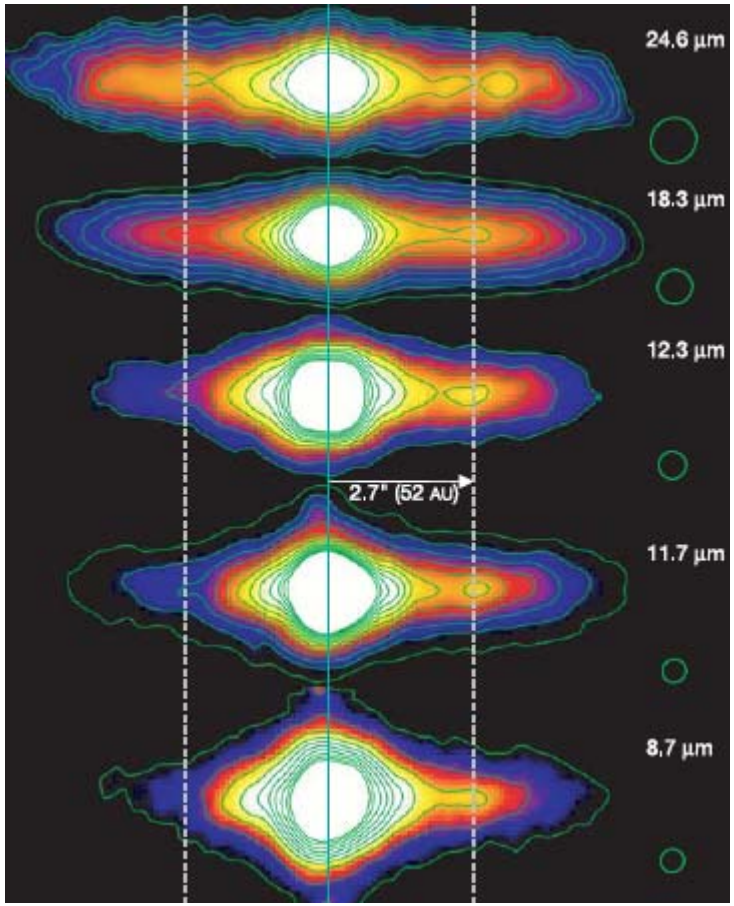
30m

20μm dust emission at 40pc (Wilner et al)

Debris disks with planet: beta Pic



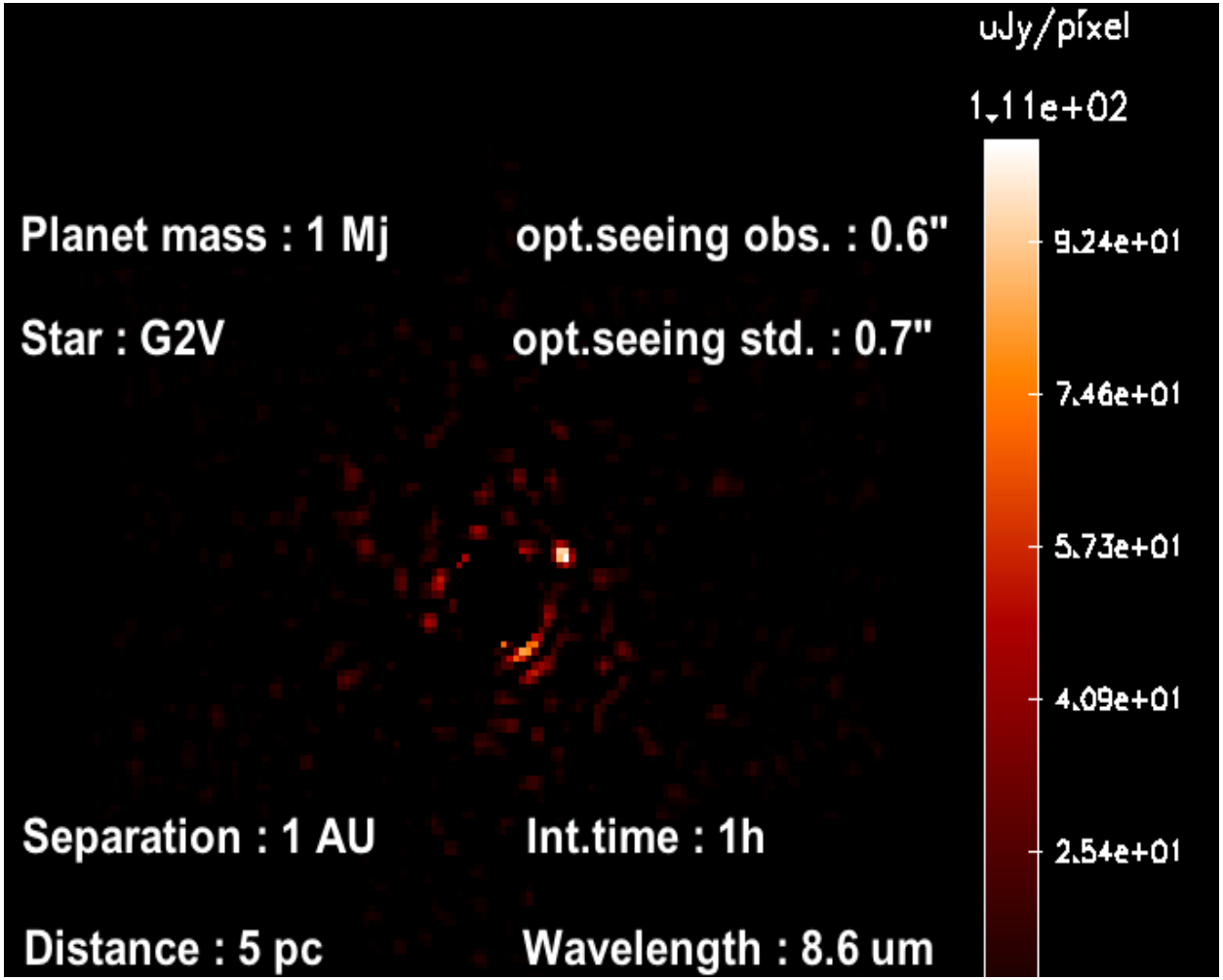
Lagrange et al. 3.6μm



Telesco et al. 8-25μm

ELT -> Statistics on the debris disk structure

Thermal emission of a planet



Pantin et al. '08