Report from the

Cradle of Life Science Working Group

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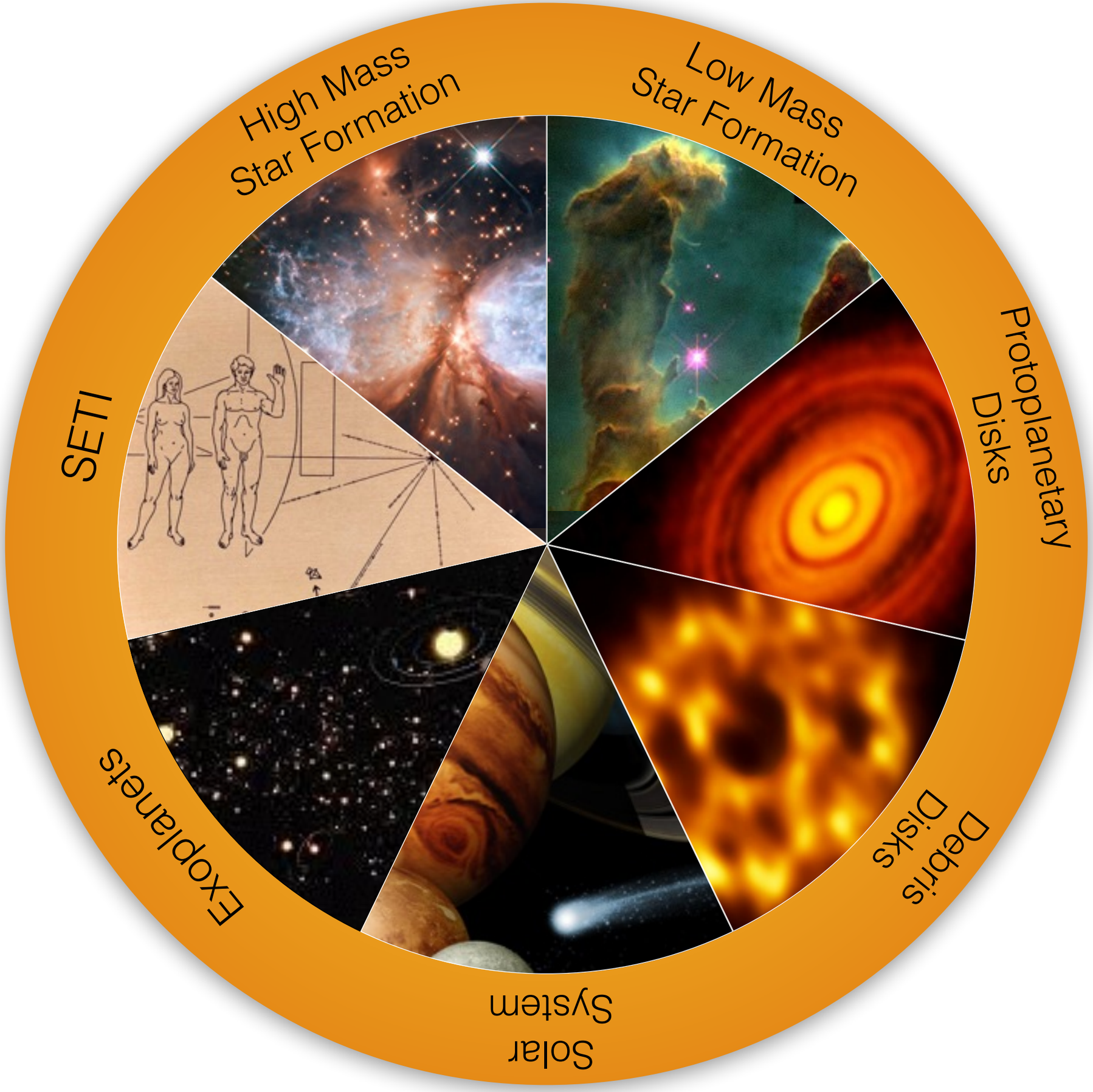
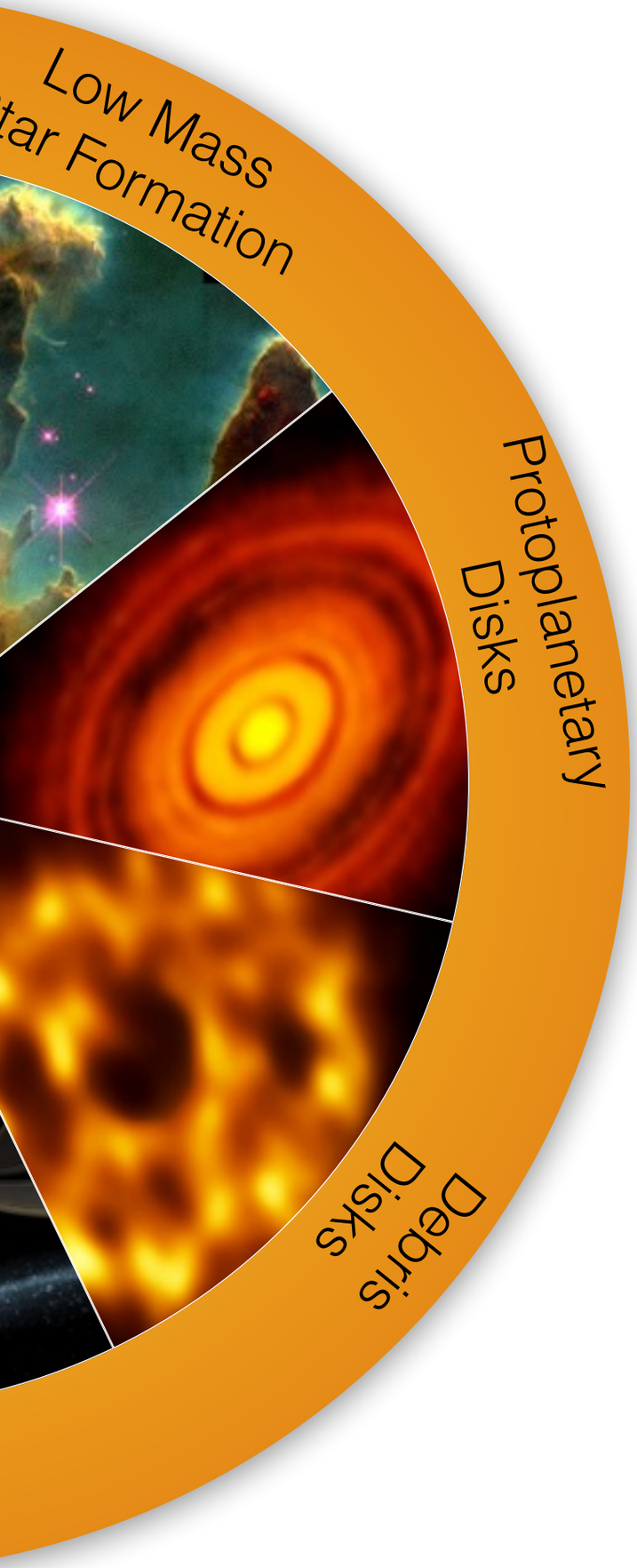
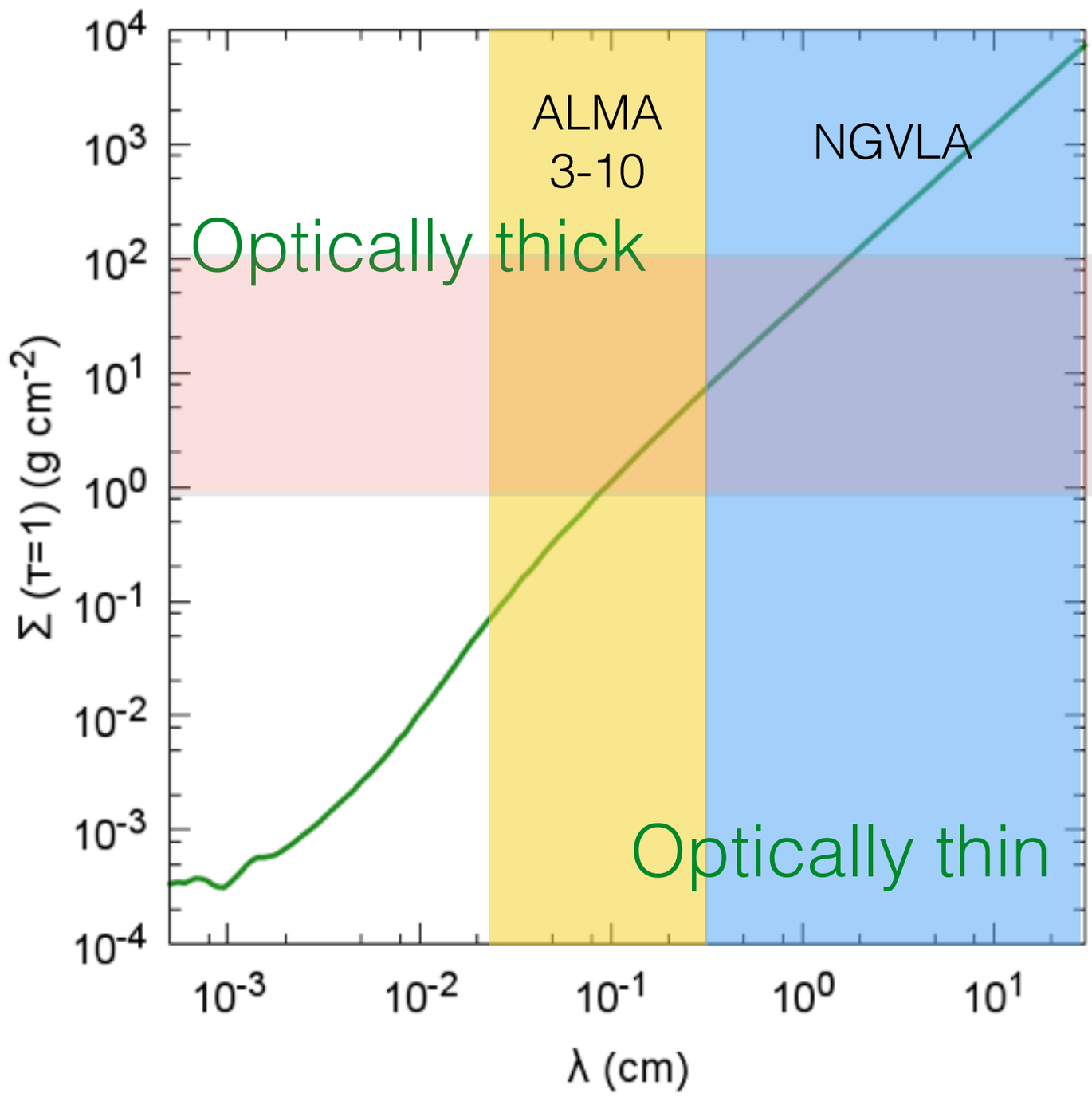
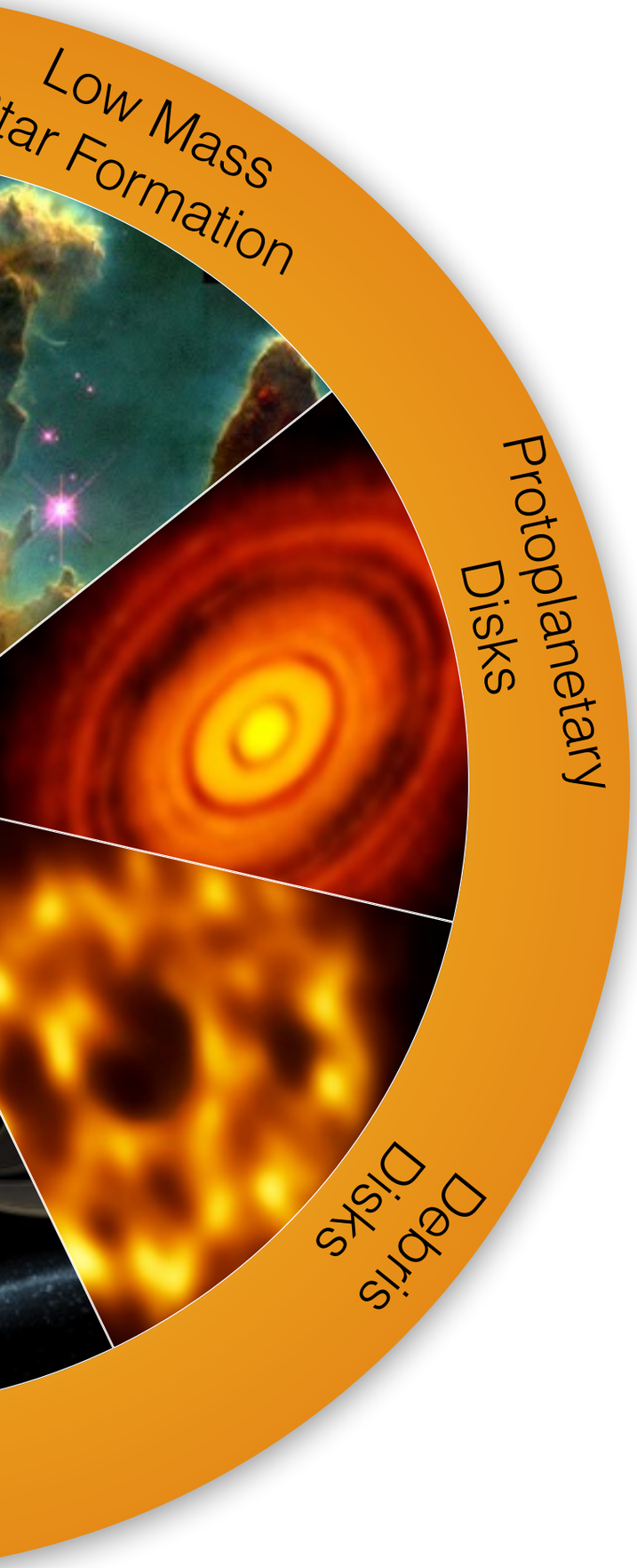

High Mass
Star Formation
Low Mass
Star Formation
Protoplanetary
Disks
Debris
Disks
Solar
System
Exoplanets
SETI



Dusty Environments



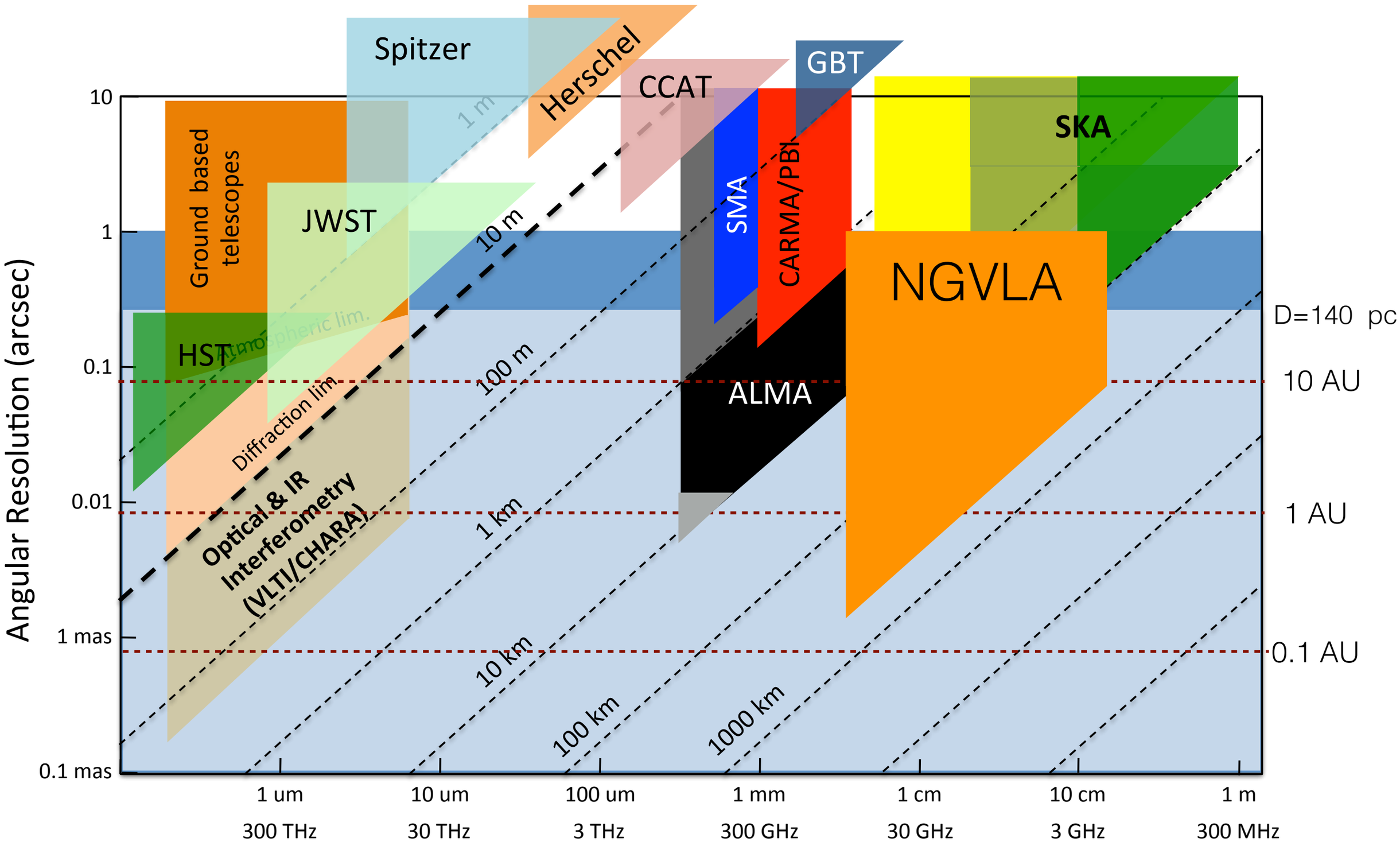


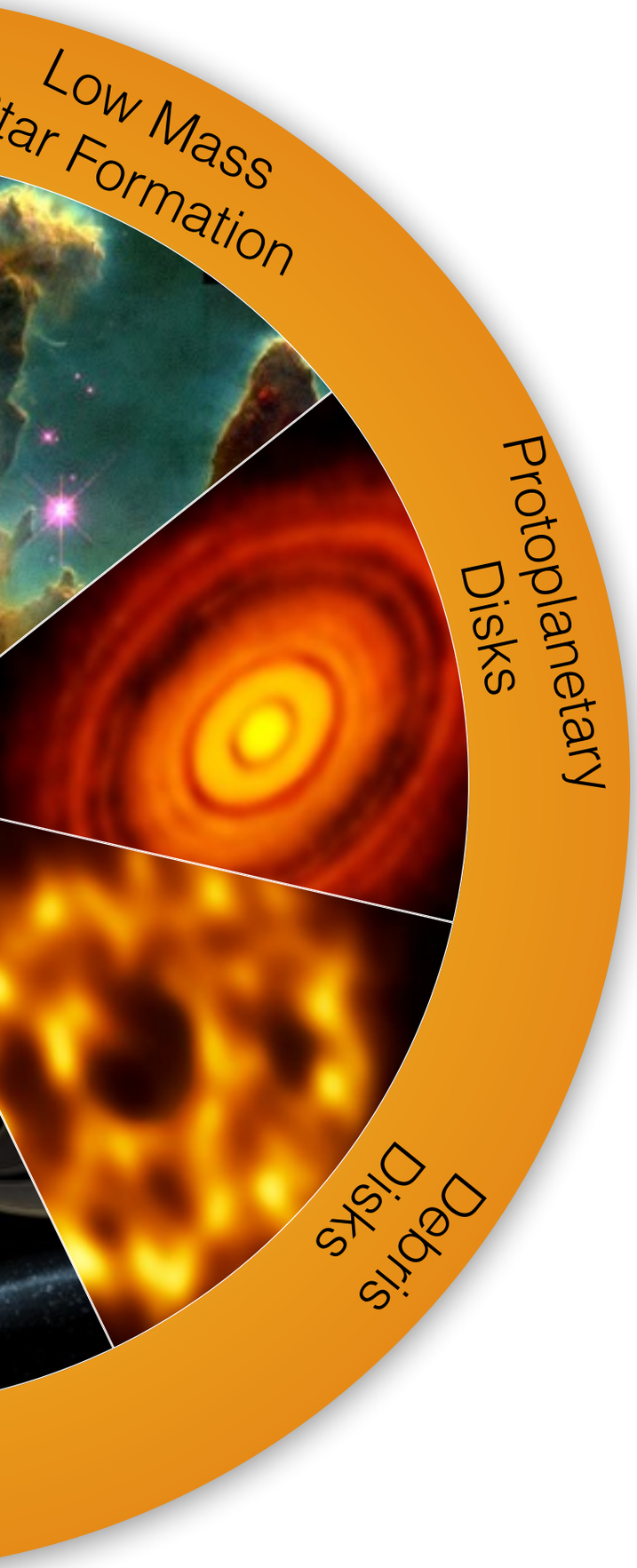
Compact Objects

Protostellar disks ..... < 10^3 AU
(Hyper/Ultra) Compact HII regions .. < 10^3 AU
Protoplanetary disks .....< 10^2 AU
Planet forming region ..... < 10 AU

Require angular resolution between 1-1000 mas

Angular Resolution is Critical





Planet Formation Imager

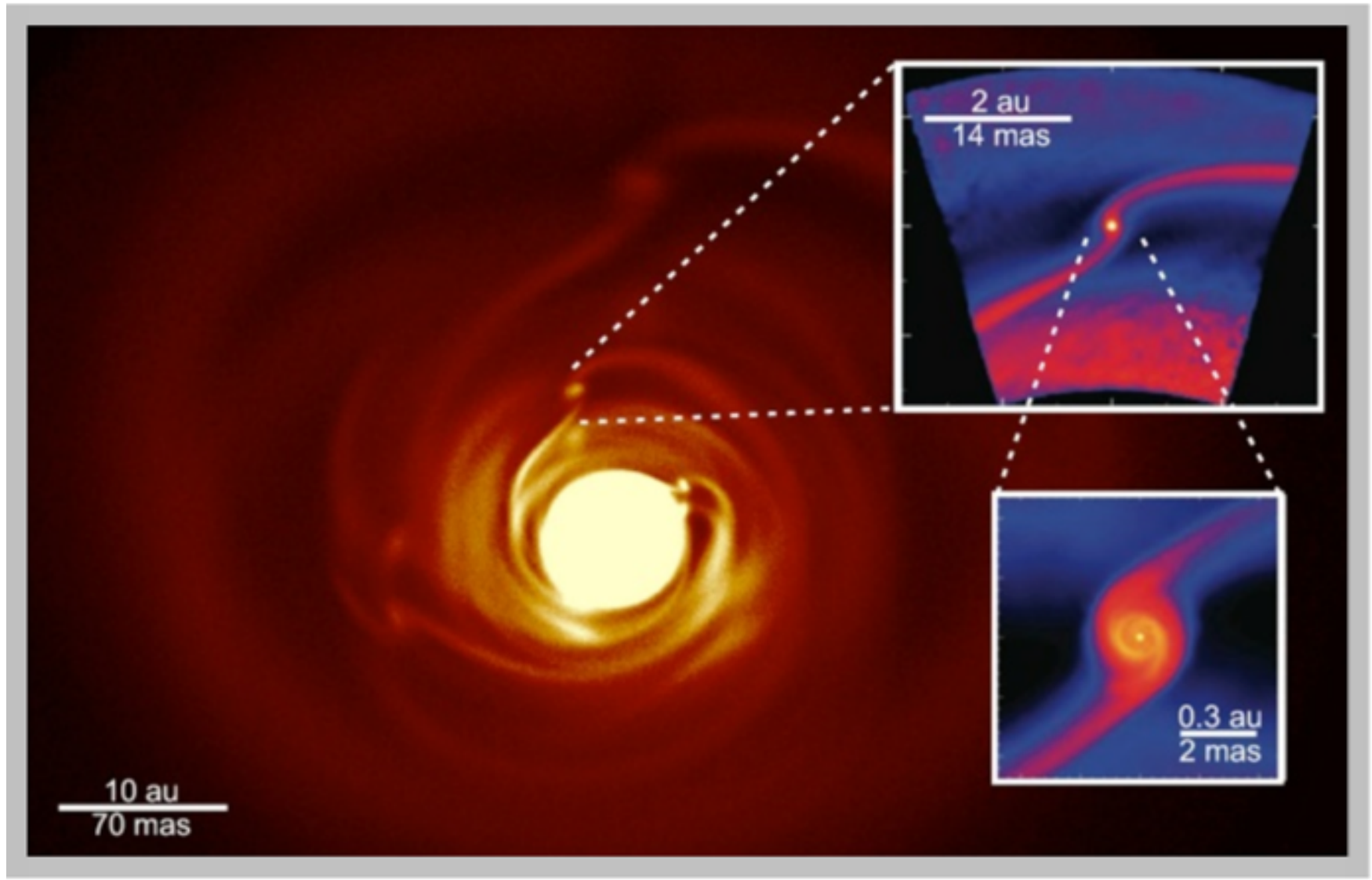
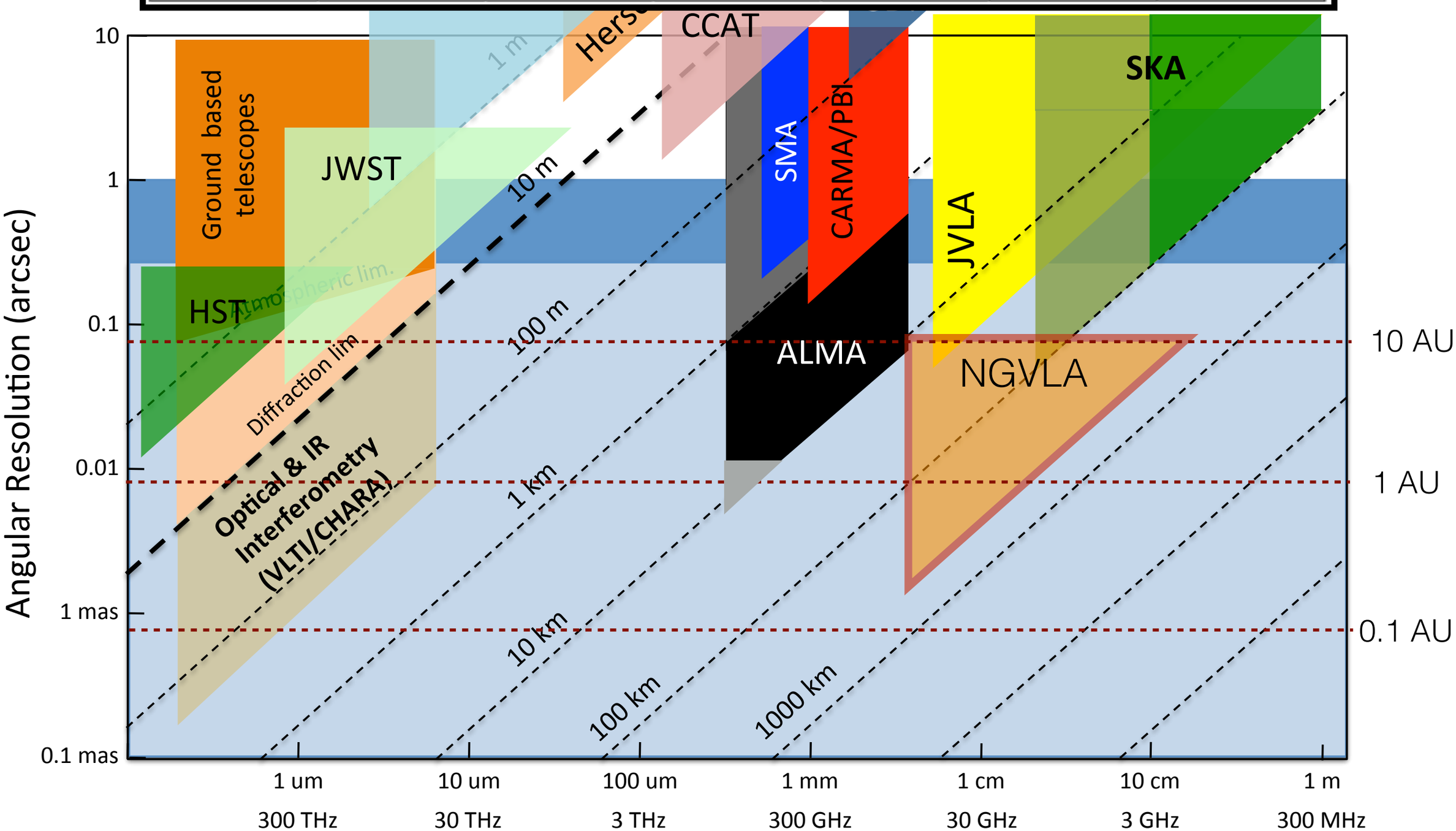
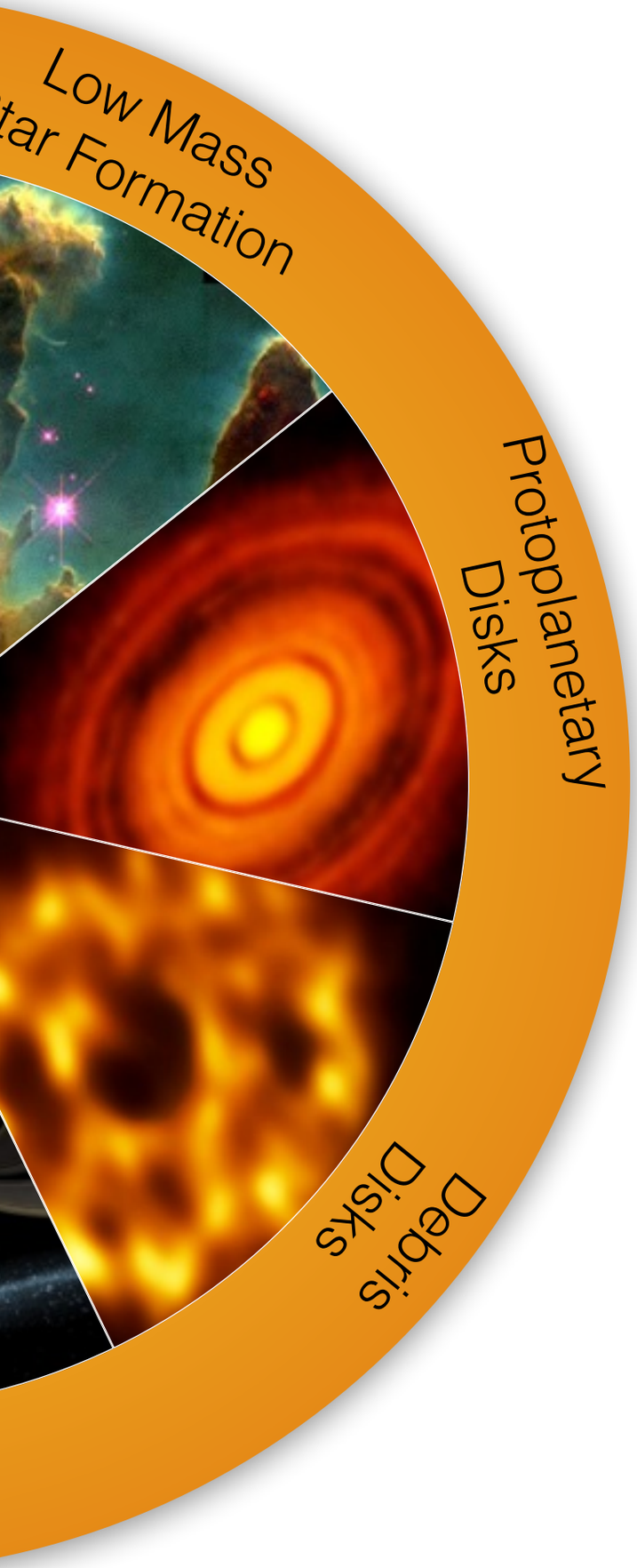


Image credit: Kraus et al. (2014)

Continuum Image rms in Kelvin (10 hours, natural weighting)						
	Max B (5-15GHz)			Max B (20-40GHz)		
Area	36.4km	182km	364km	36.4km	182km	364km
1 x VLA	0.070	1.75	7.0	0.129	3.23	12.9
5 x VLA	0.014	0.35	1.4	0.026	0.65	2.6
10 x VLA	0.007	0.17	0.7	0.013	0.32	1.3





Chemistry of planet forming regions

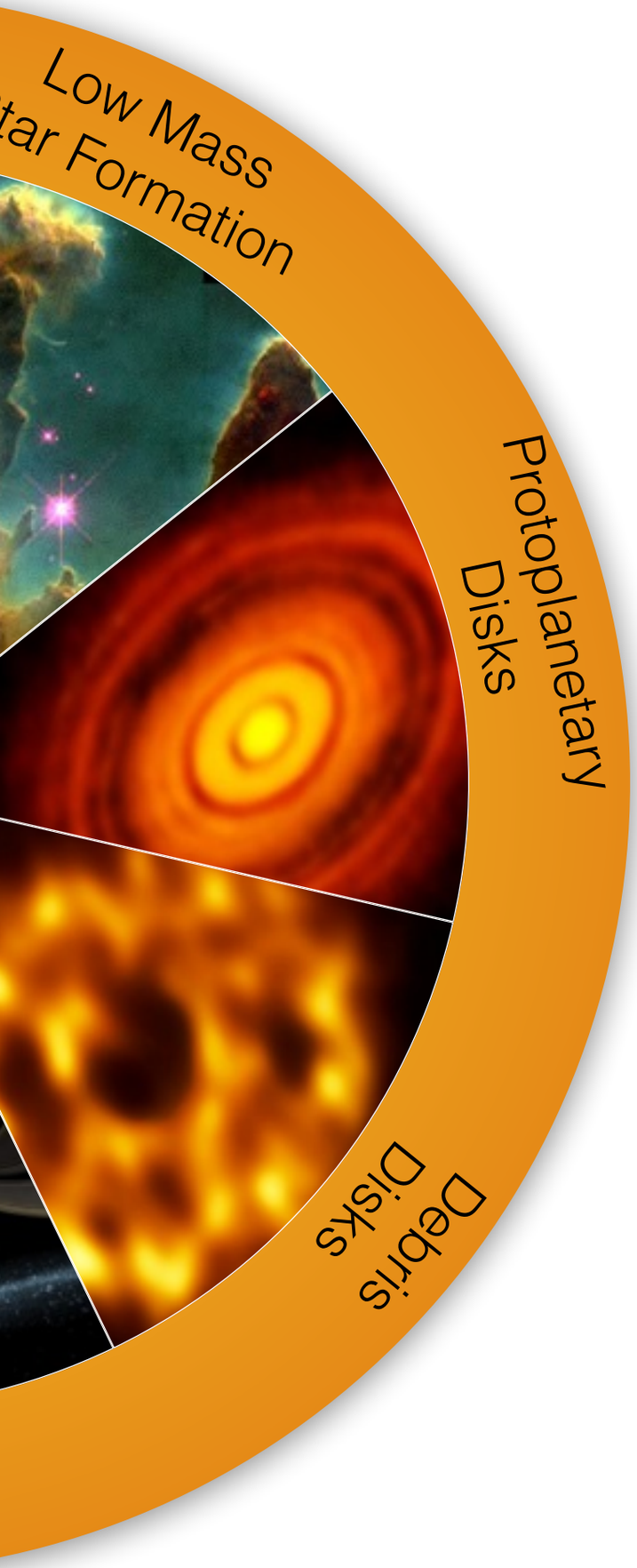
The low frequencies of the NGVLA (compared to ALMA) gives access to:

1. Ammonia (NH3) one of the most (perhaps the most) important N-bearing volatile,

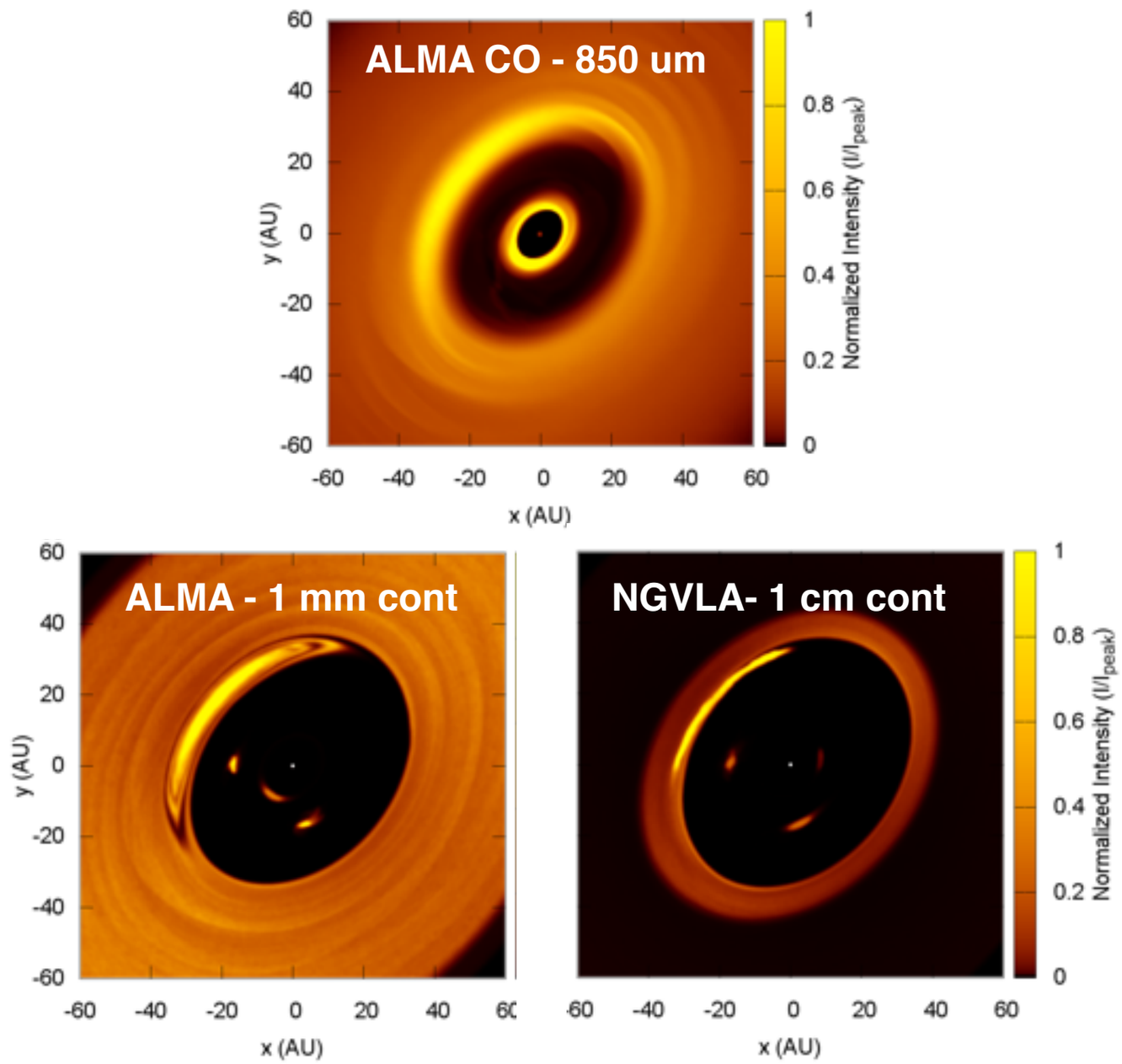
2. volatile molecules in very dense regions, e.g. the innermost parts of protoplanetary disks, that are otherwise veiled by optically thick dust at shorter wavelengths,

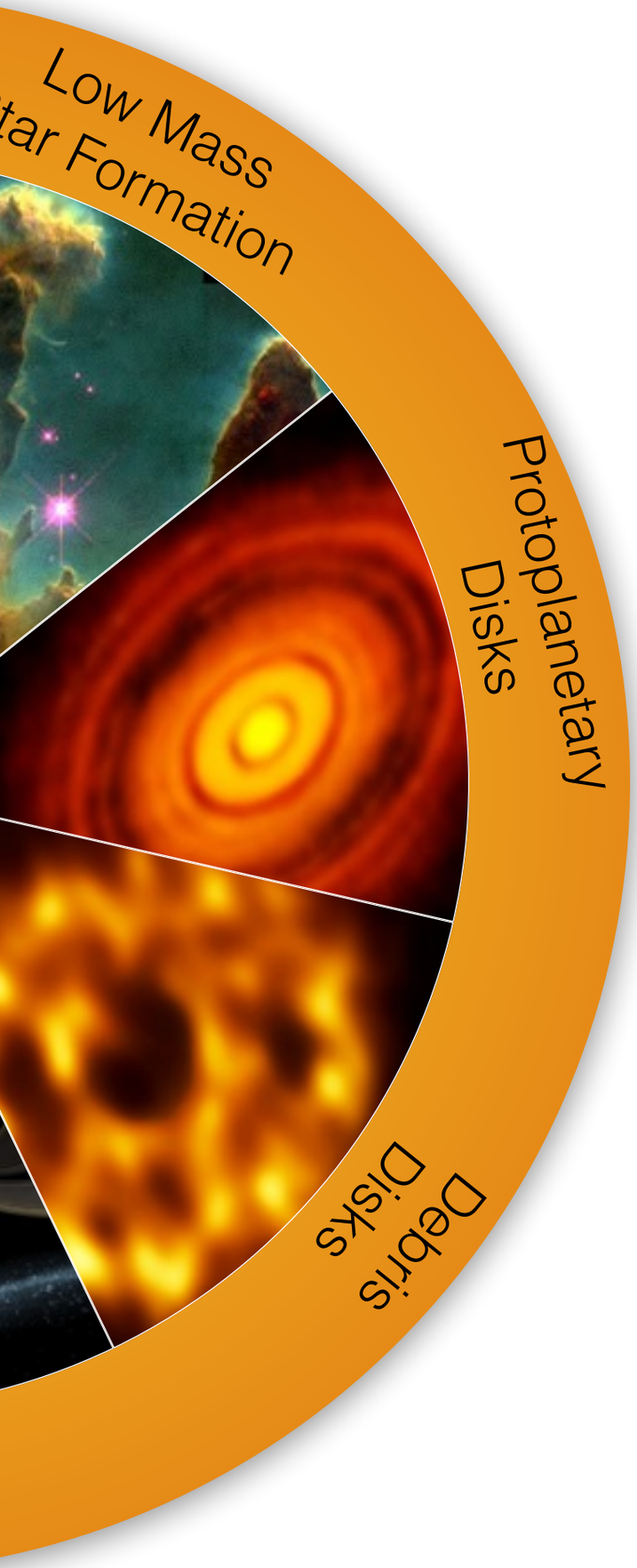
3. low-lying excitation modes of moderately complex organic molecules, enabling the observations of molecules such as CH3CN in the cold regions where they are proposed to form through ice chemistry, and

4. lines of very complex organic molecules such as glycine because of a lower line density at cm wavelengths compared to mm wavelengths.



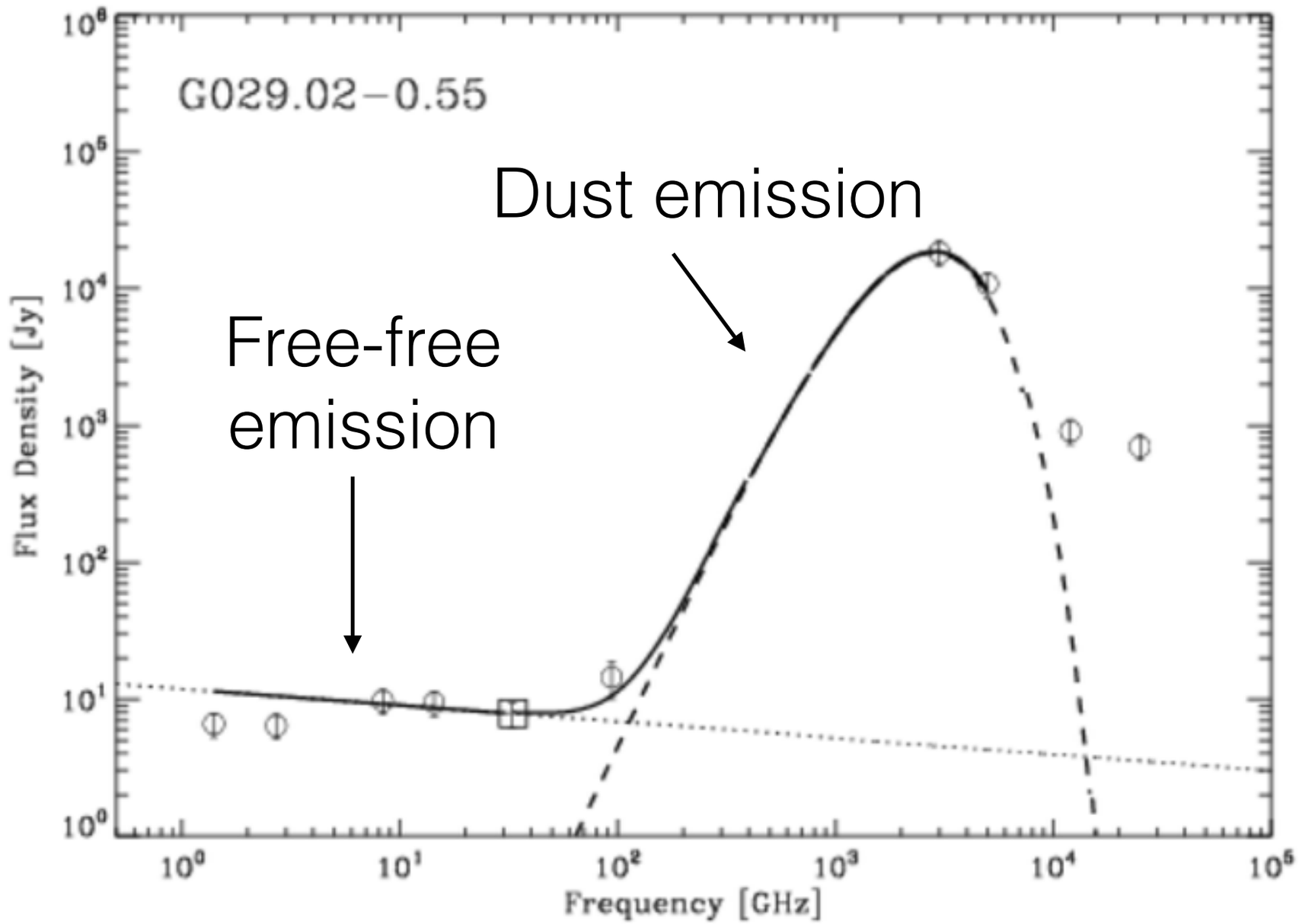
From Dust to Planets

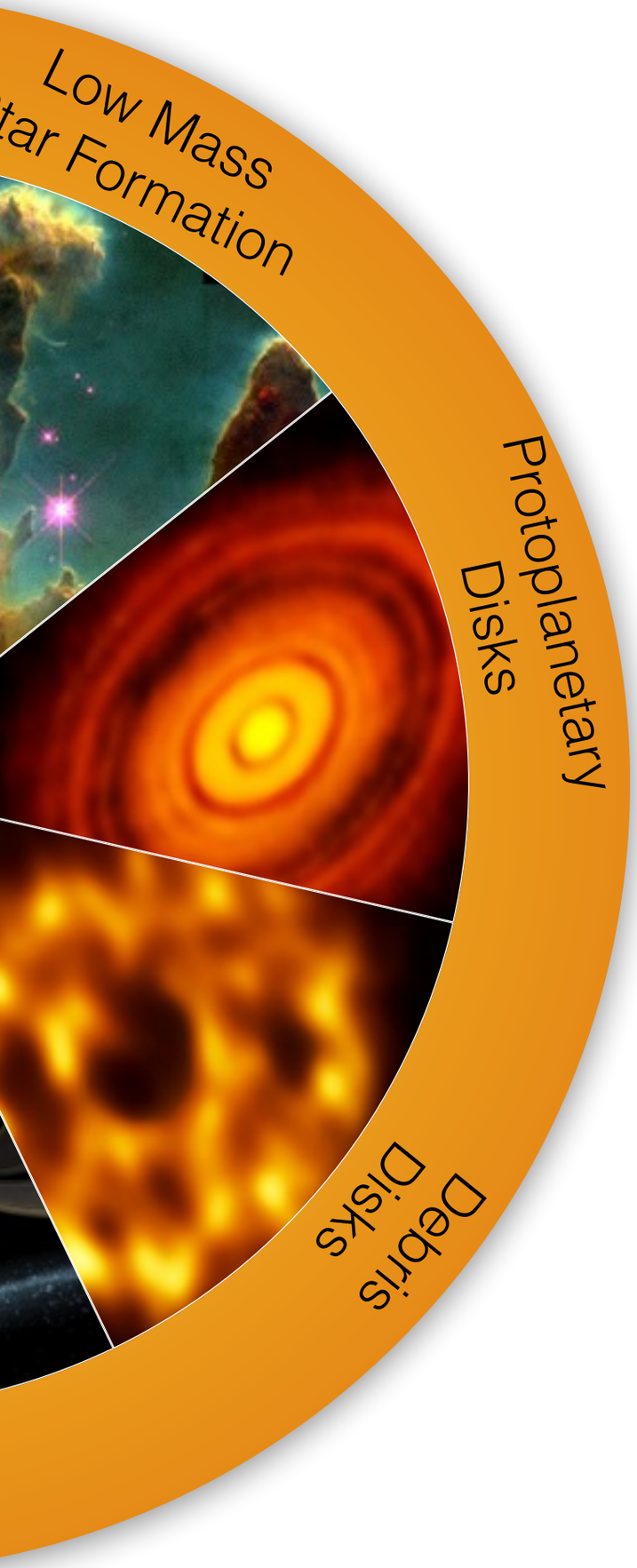




Not only dust !

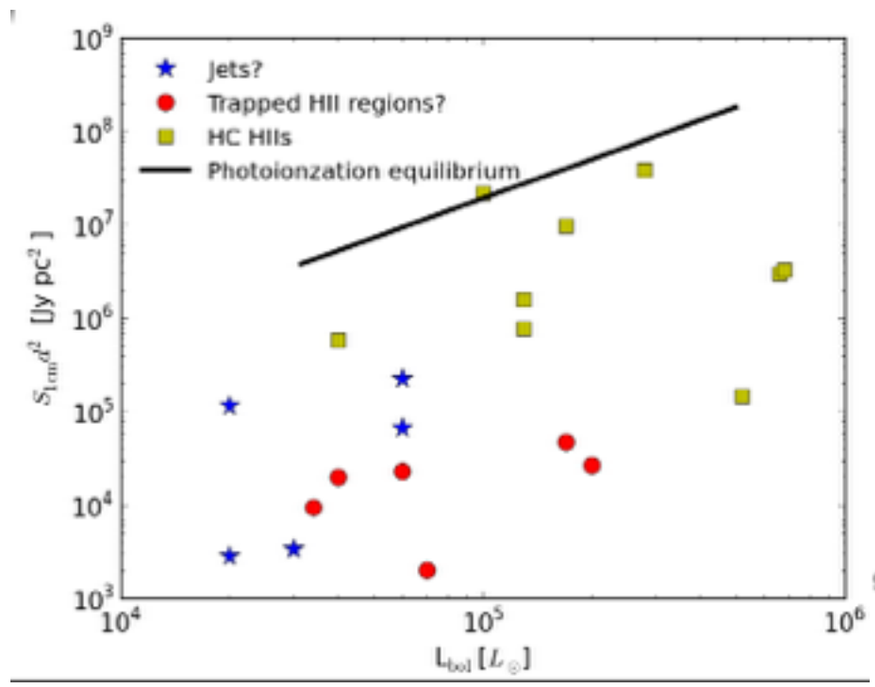
Spectrum of an HII region on the Galactic plane

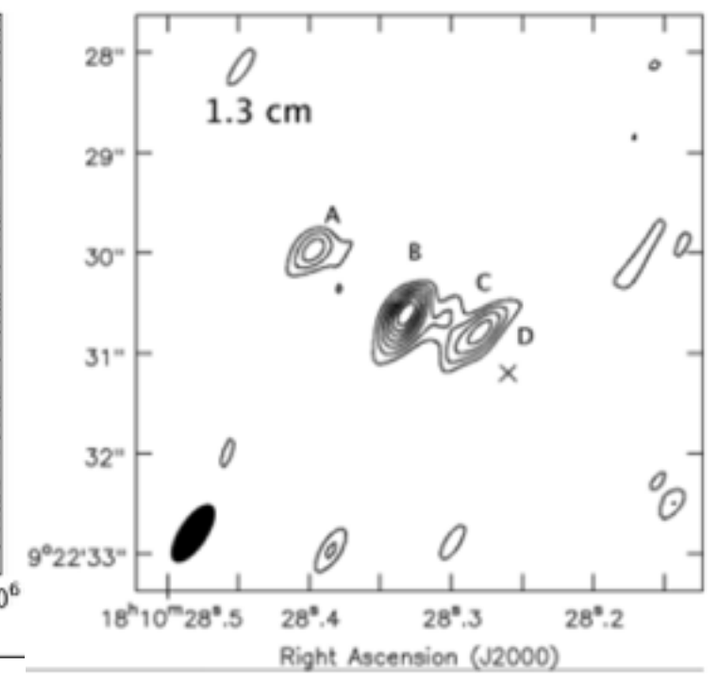




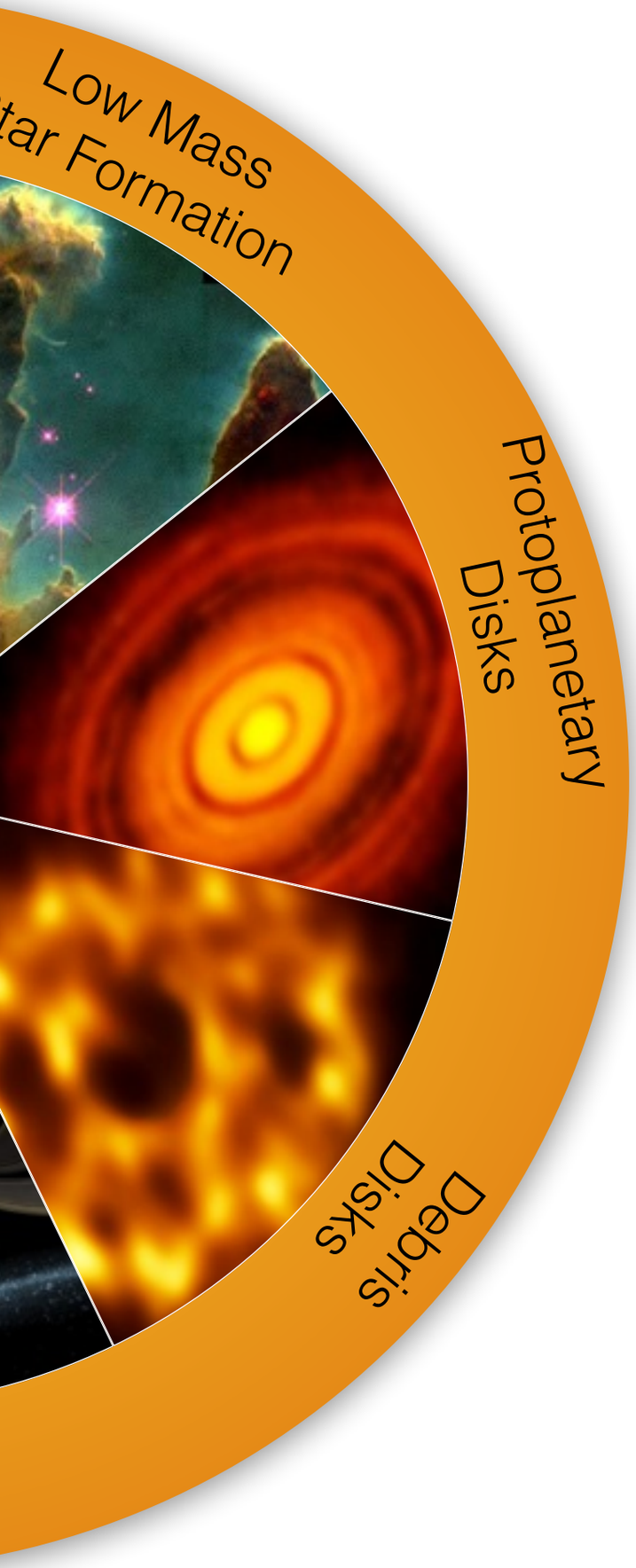
High Mass Star Formation

1. Resolving the inner ionized regions of accreting massive stars (Mstar > 10 Msun)





Right: G11.11, S1.3cm ≈ 100 μJy, θ < 300 mas (Rosero+2014)

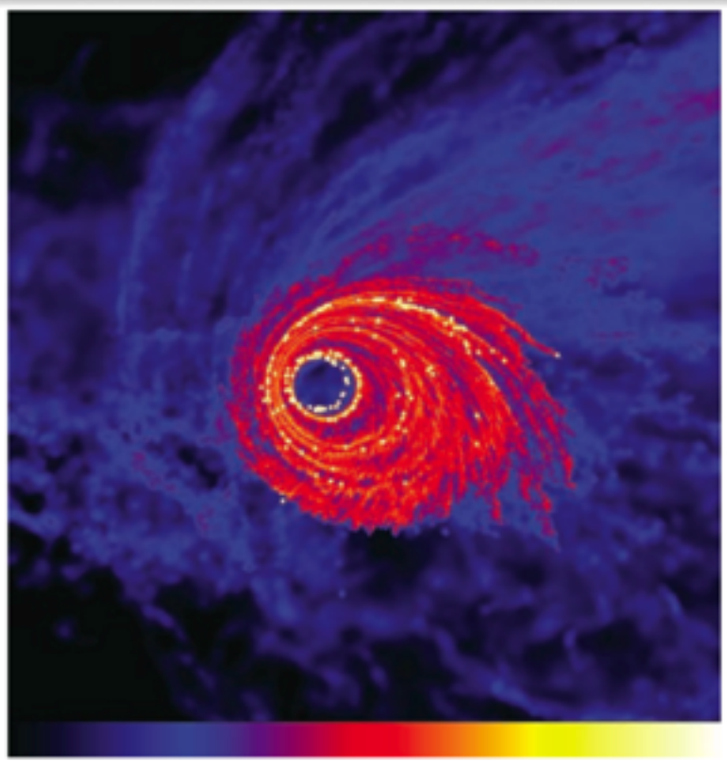


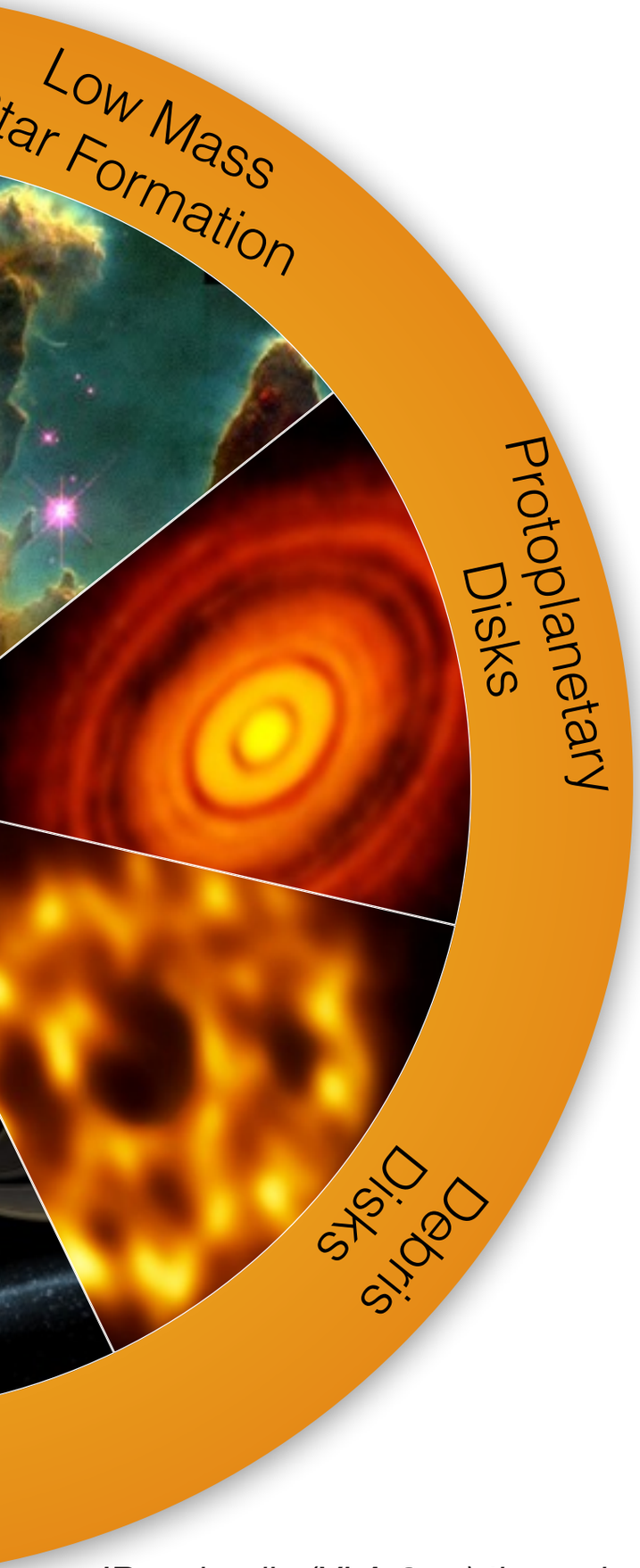
High Mass Star Formation

2. Star formation in the inner 2-4 pc in the Galactic Center

- Is star formation in the extreme environment of the Galactic center possible, and if yes, different from SF in the Galactic disk?
- 10 mas (80 AU) resolution can resolve circumstellar disks/jets around Sgr A*
- Coverage from few GHz to 50-100 GHz is needed to disentangle dust from free-free

Simulation of SF around a supermassive black hole of MBH = 3 × 106 M⊙ (Bonnel & Rice, 2008)



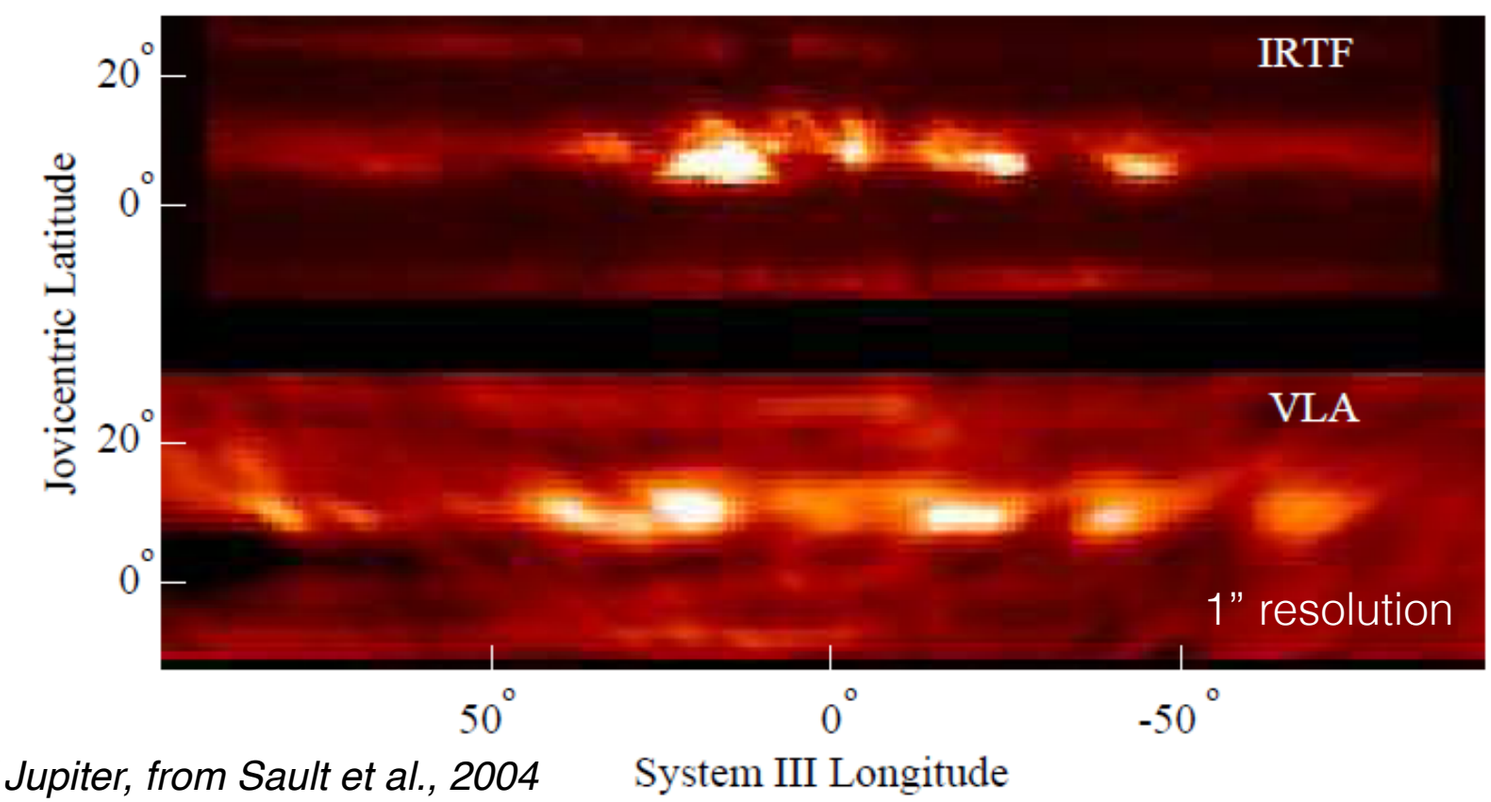


Mapping deep atmospheres of giant planets

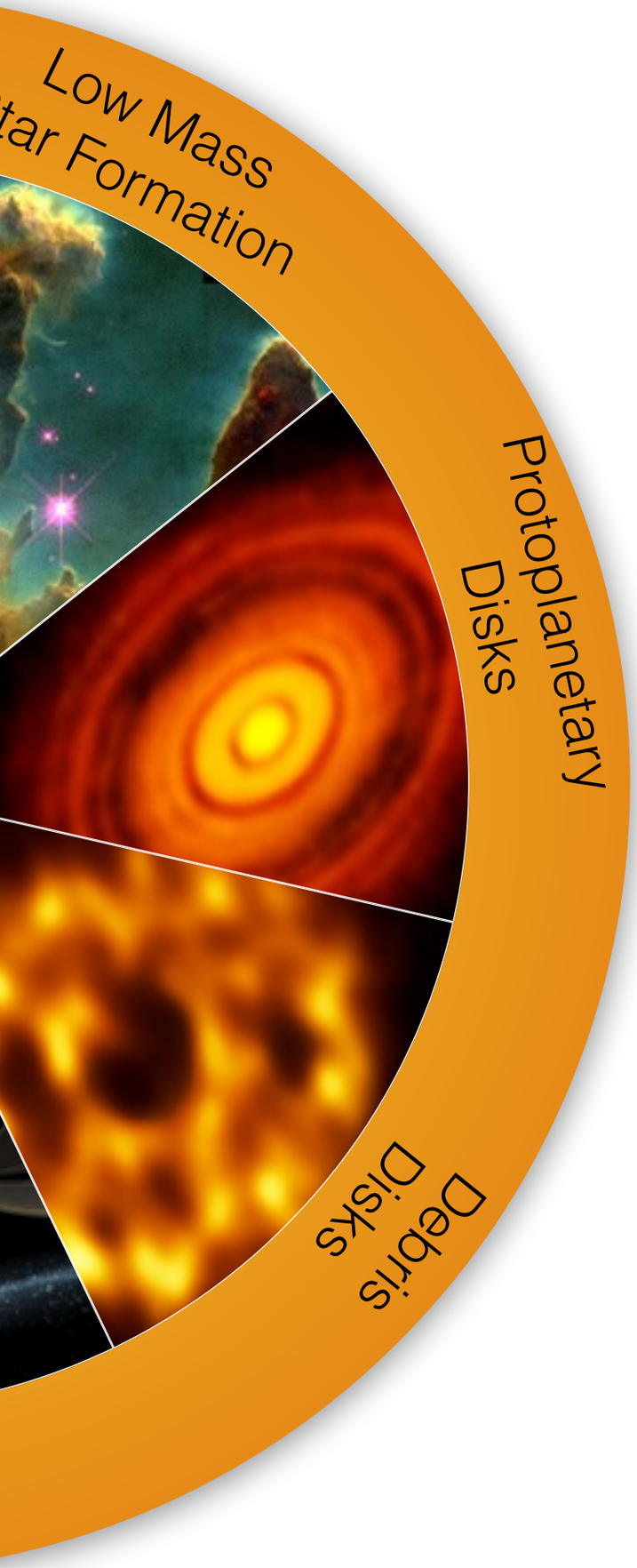
Maps at 5-100 GHz: 3-D distribution of temperature and absorbers in deep atmospheres (troposphere, < 1 bar) :
-> tracing deep atmospheric dynamics

<u>NGVLA resolution</u>: storms and small scale features on Jupiter / Saturn, mapping of Neptune / Uranus

<u>NGVLA sensitivity</u>: longitudinal resolution on fast-rotating planets



IR and radio (VLA-2cm) thermal maps of Jupiter, from Sault et al., 2004



- Detection and mapping of water in comets and planetary atmospheres (H_20 line at 22 GHz)

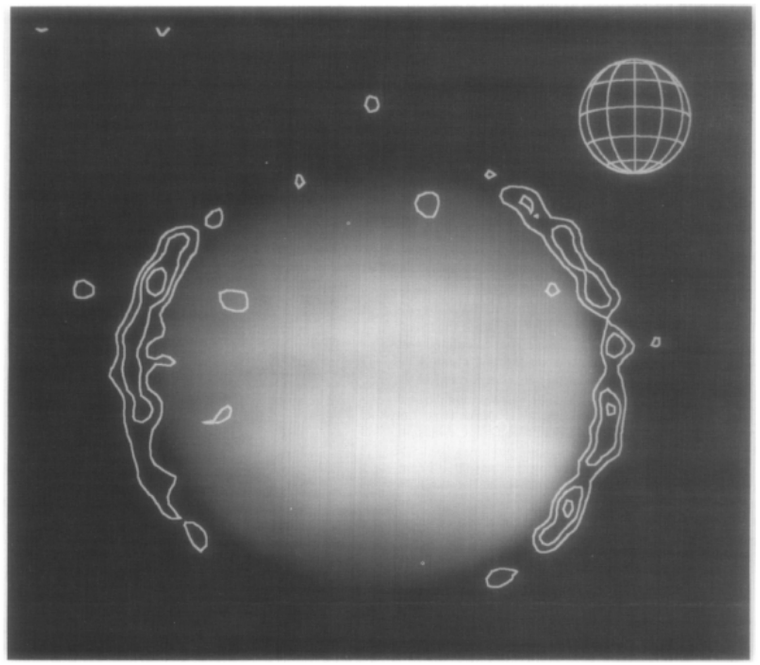
→ Mars water distribution monitoring, water plumes detection on moons, asteroids

- Detection of faint ammonia line in comets (24 GHz)

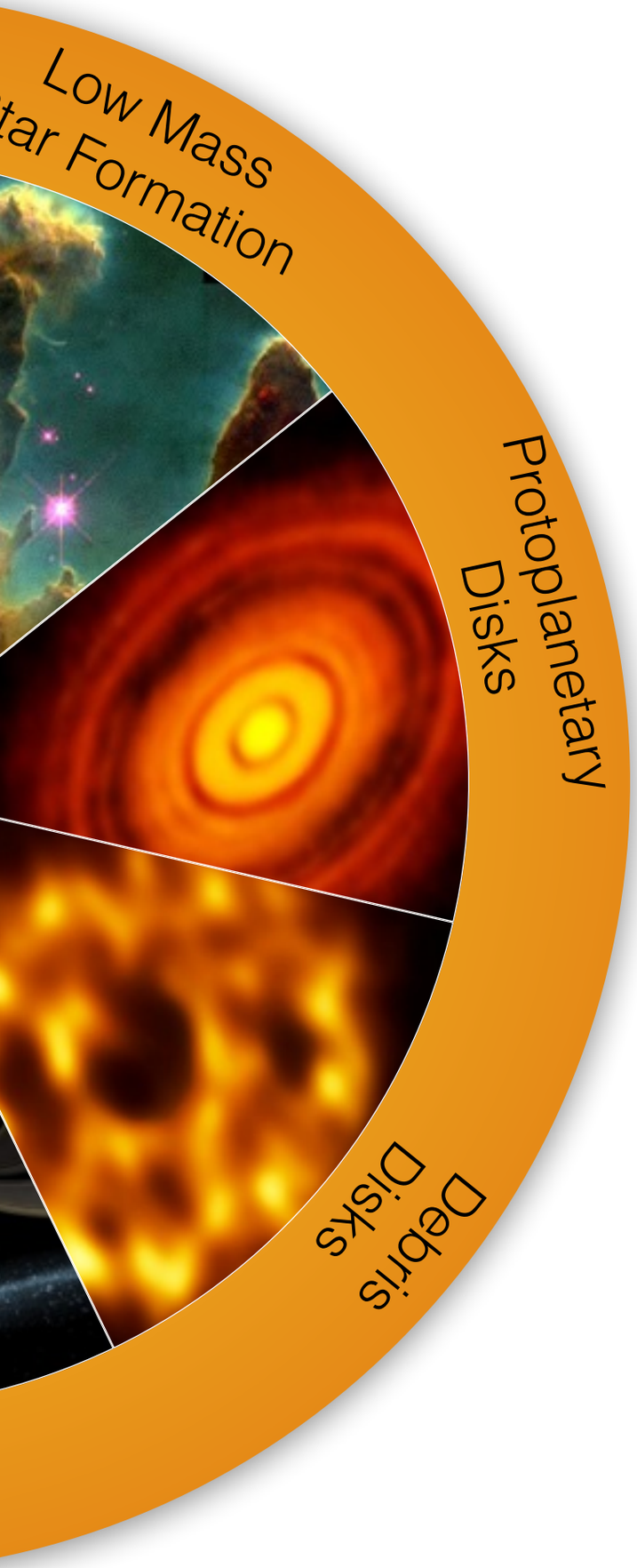
→ ammonia/water ratio near nuclei links to primordial disk ratio

- Radar observations of Near Earth Asteroids

→ best precision for orbit and shape determination



Water line mapping on Mars' limb with VLA, from Clancy et al., 1992



Search for narrow-band coherent (artificial) radio signal

New SETI targeted searches based on GAIA / TESS / Kepler-2 using SKA, ATA

NGVLA: complements SKA spectrum, sensitivity (5 x EVLA) to detect aircraft radars from dozens nearby stars in 10 min

<u>Optimal observation mode</u>: Multi-beam phased array, wide bandwidth. Possibility of commensal observations ('piggy-back')

Transmitter Type	Luminosity (EIRP) (ergs/sec)
Interplanetary Radar	~2 x 10^{20}
Long Range Aircraft Radar	~1 x 10^{17}
High Power TV and Radio	~5 x 10^{12}

Artificial terrestrial radio sources, from Siemion et al., 2014

https://safe.nrao.edu/wiki/bin/view/NGVLA/CradleOfLifeSWG