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## Exploring the architectures of nearby exoplanetary systems using high-precision space astrometry

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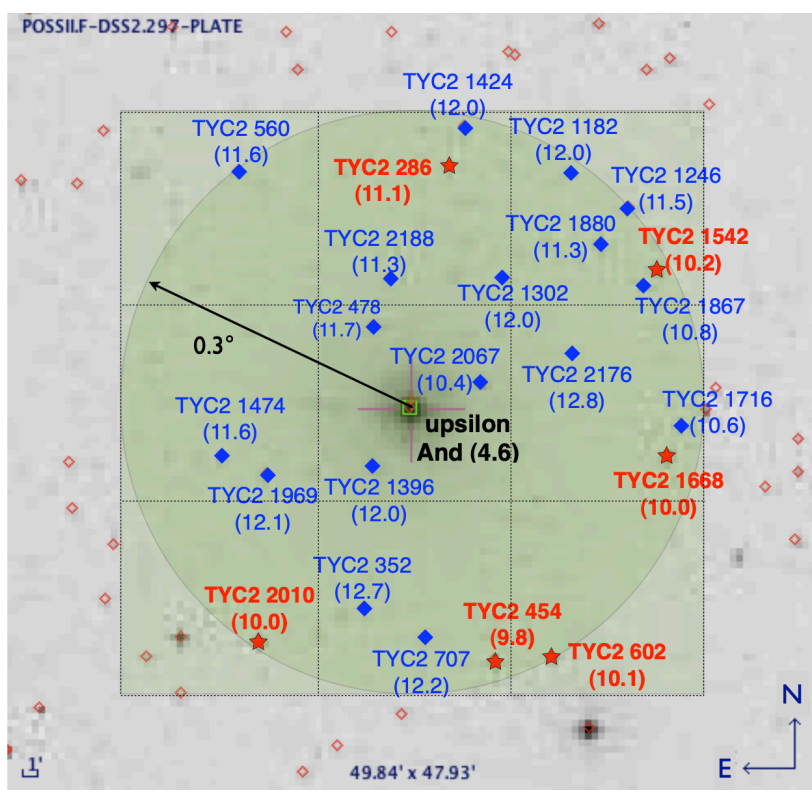
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# Exploring the architectures of nearby exoplanetary systems using high-precision space astrometry

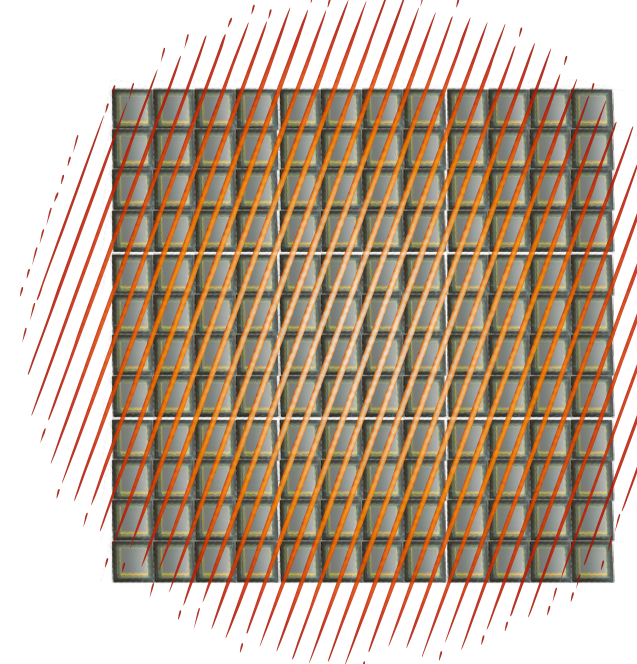
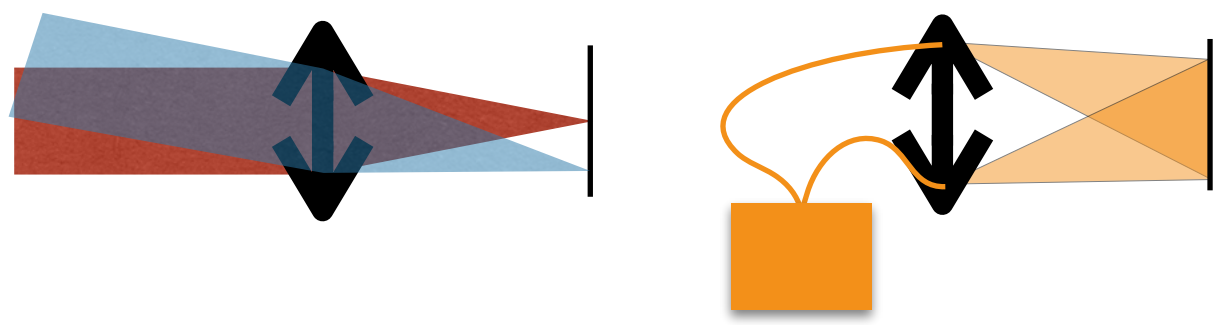
F. Malbet (1), M. Lizzana (1,2), A. Léger (3), G. Mamon (4), L. Labadie (5), A. Sozzetti (6), T. Lépine (7), R. Goullioud (8), and Theia collaboration (9)

See poster 1180 (M. Lizzana) for instrumental results

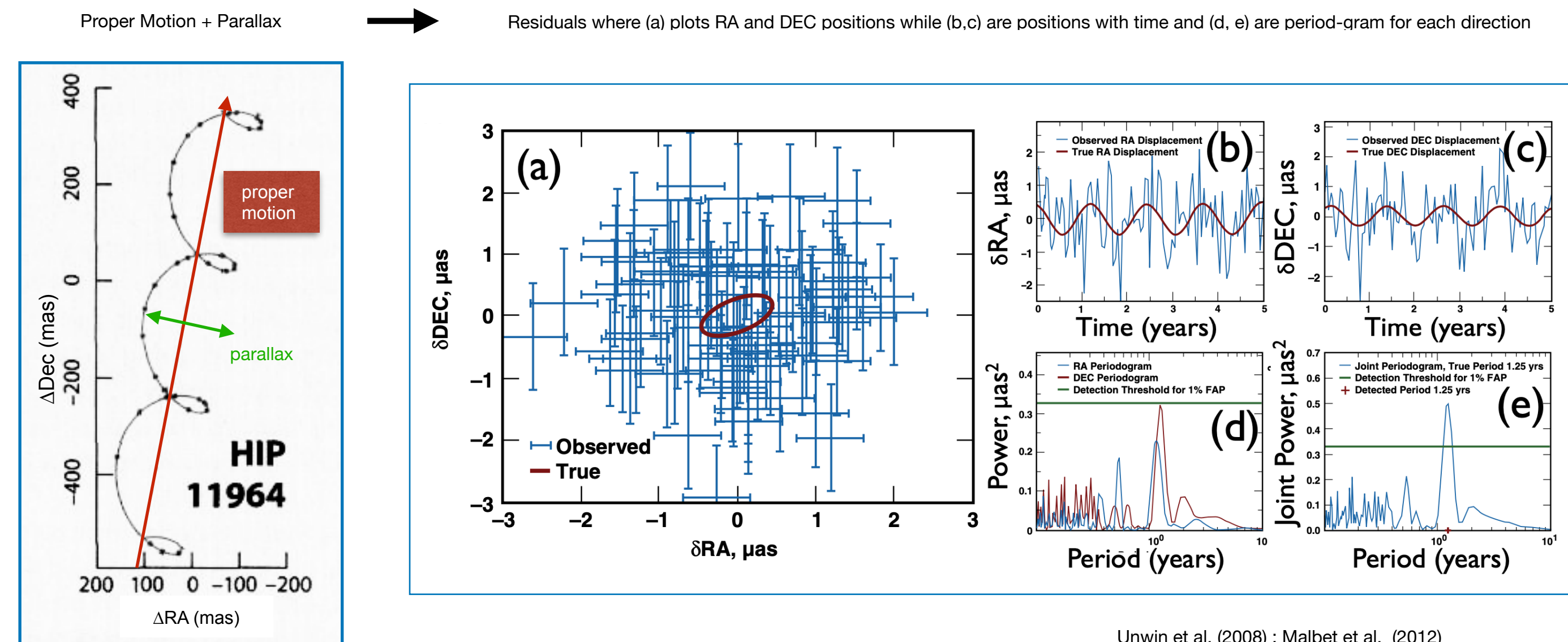
## Principle of Theia : relative and precise differential astrometry



- ✓ The science target is at the center of the FOV
- ✓ We measure the offset angles between the target object (in black) and the reference stars (other stars in red and blue)
- ✓ The single measurement is repeated several times over the mission lifetime to reach the required accuracy on the target motion
- ✓ The detector calibration is done using interferometric modulated Young's fringes



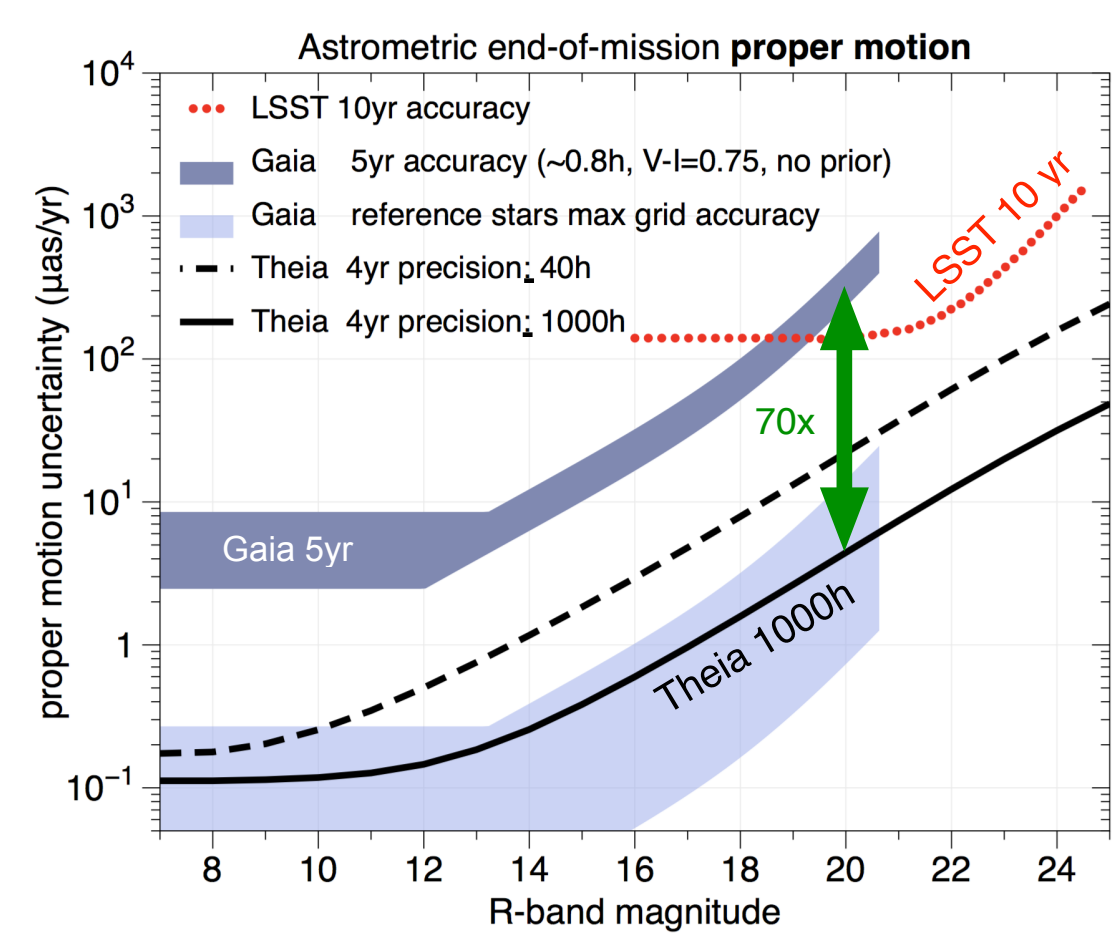
## Astrometry: parallax, proper motion and reflex motion



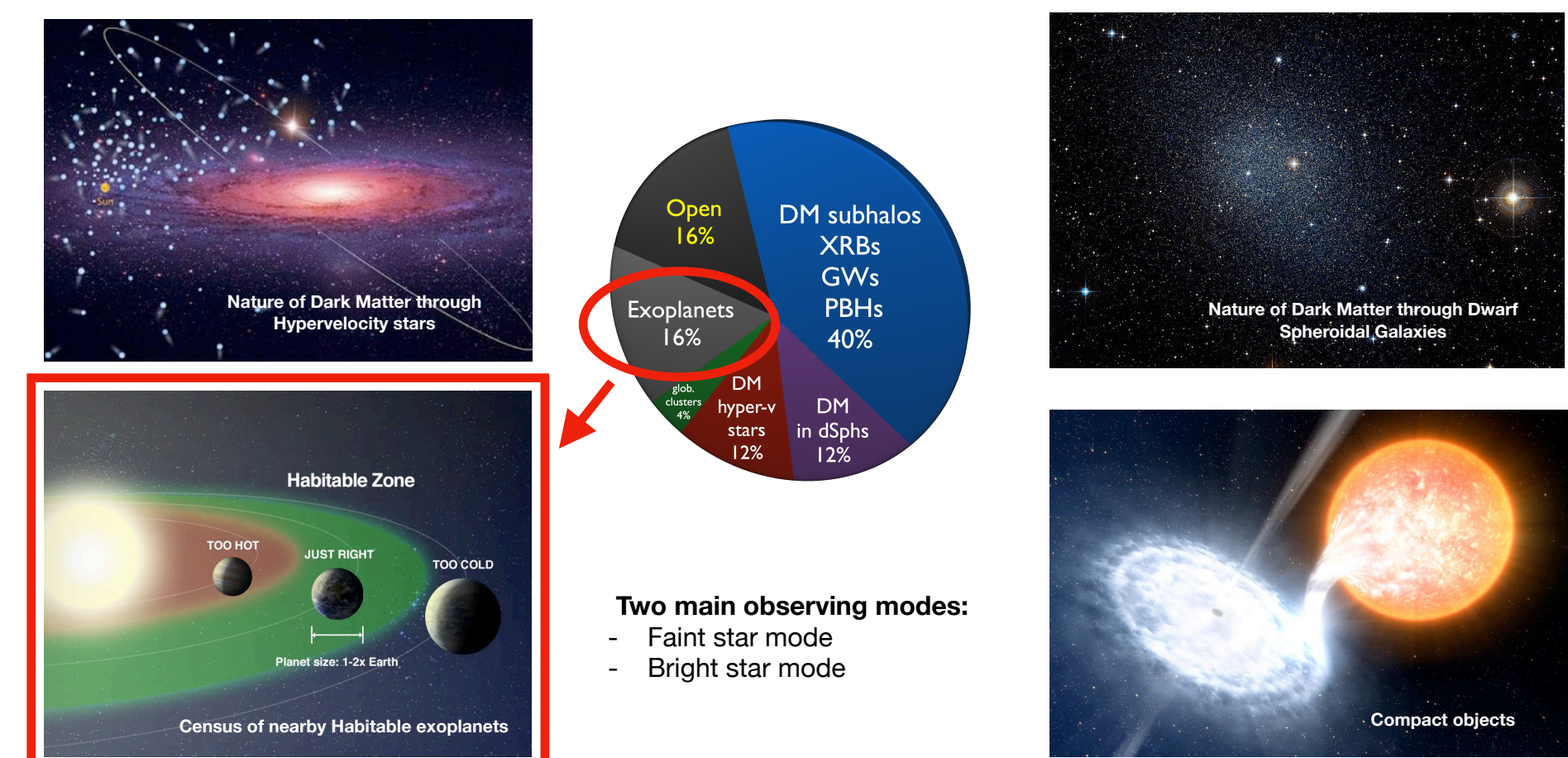
Unwin et al. (2008) ; Malbet et al. (2012)

## Improvement compared to Gaia

	Gaia post-launch	Theia	Improvement
Telescope Aperture	1.49 x 0.54 = 0.80 m <sup>2</sup>	0.8 → 0.50 m <sup>2</sup>	0.62
Field of view	Survey	Pointed	
Coverage	Global	Differential	
Astrometry	Global	Differential	
Exposure time per field	76 x 9 (CCD) x 4.4 sec = 0.84 hr	25 x 40 hr = 1000 hr	1200
Additional factors	2D vs 1D astrometry; 1.4, Gaia Stray light: 1.9		
Proper motion accuracy G=10 star	3.5 μas/yr	0.11 μas/yr	30
Proper motion accuracy G=15 star	14 μas/yr	0.4 μas/yr	35
Proper motion accuracy G=20 star	330 μas/yr	5 μas/yr	66

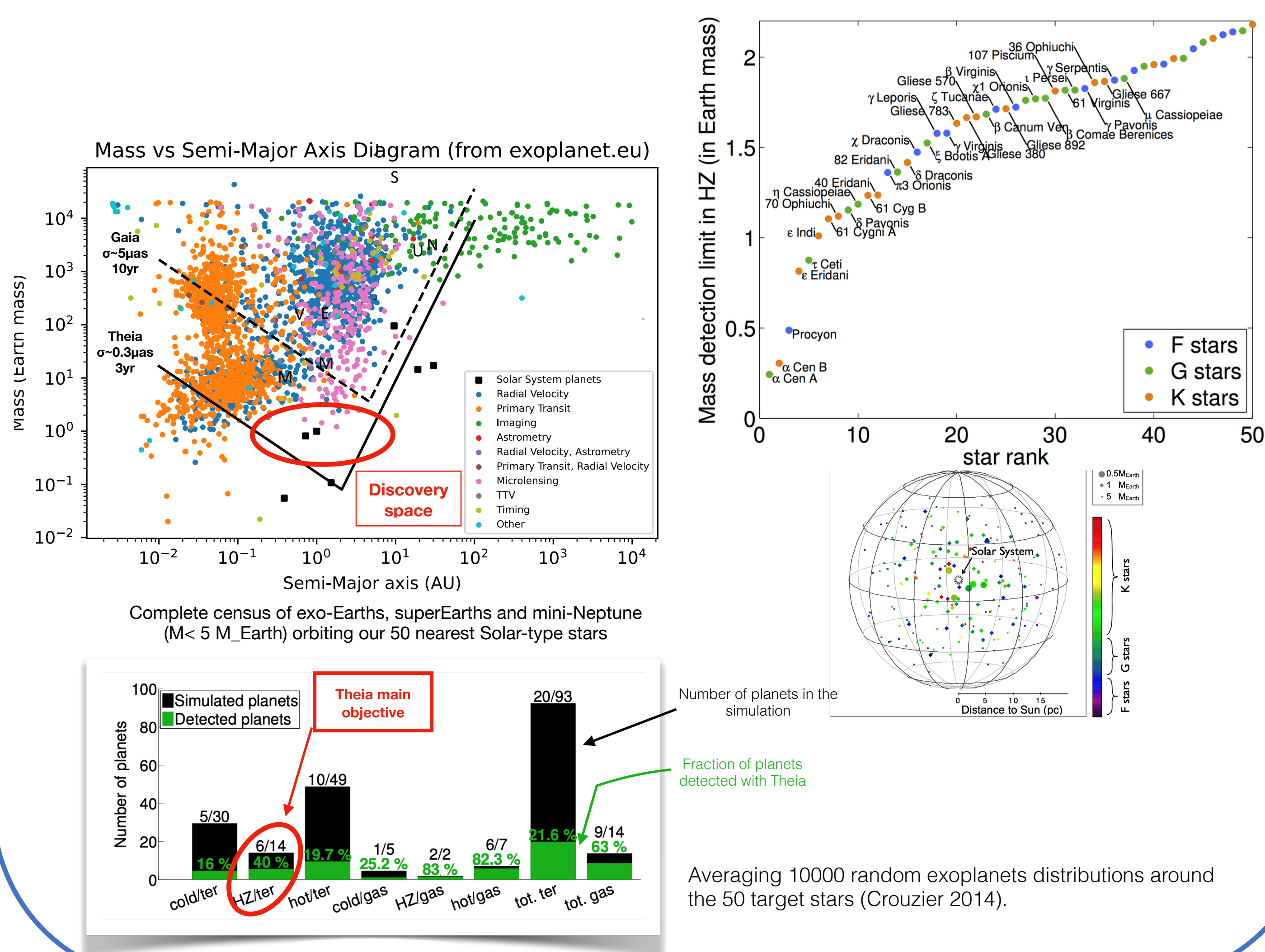


## Theia's main science based on high precision astrometry



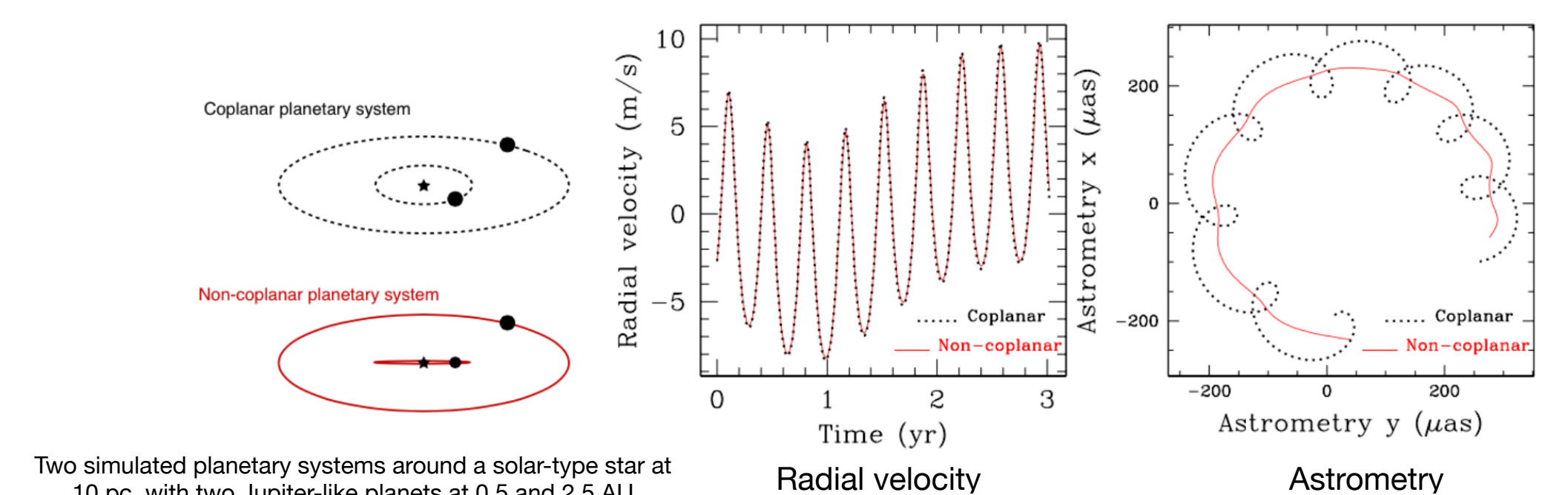
Two main observing modes:  
- Faint star mode  
- Bright star mode

## Exoplanets primary goal : Earth-mass planets in HZ in the vicinity of the Sun

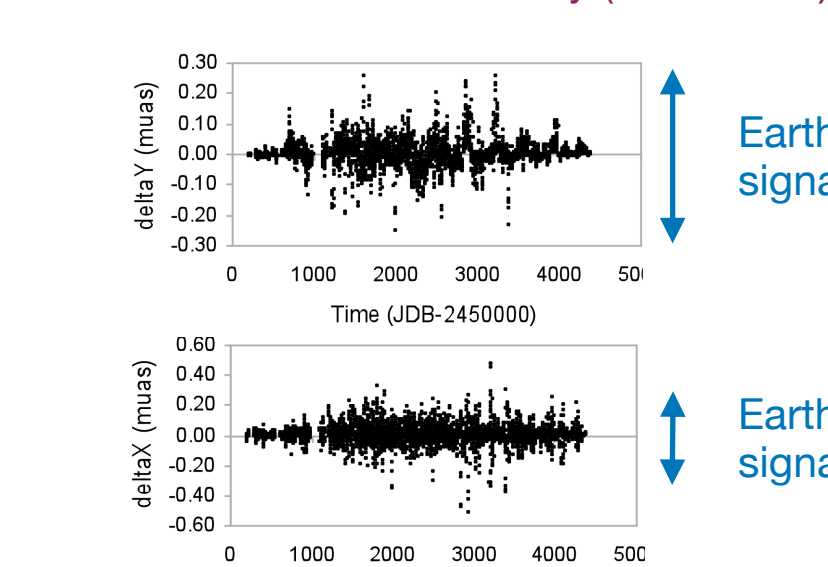


Averaging 10000 random exoplanets distributions around the 50 target stars (Crouzier 2014).

## Advantages and limitations of high precision astrometry

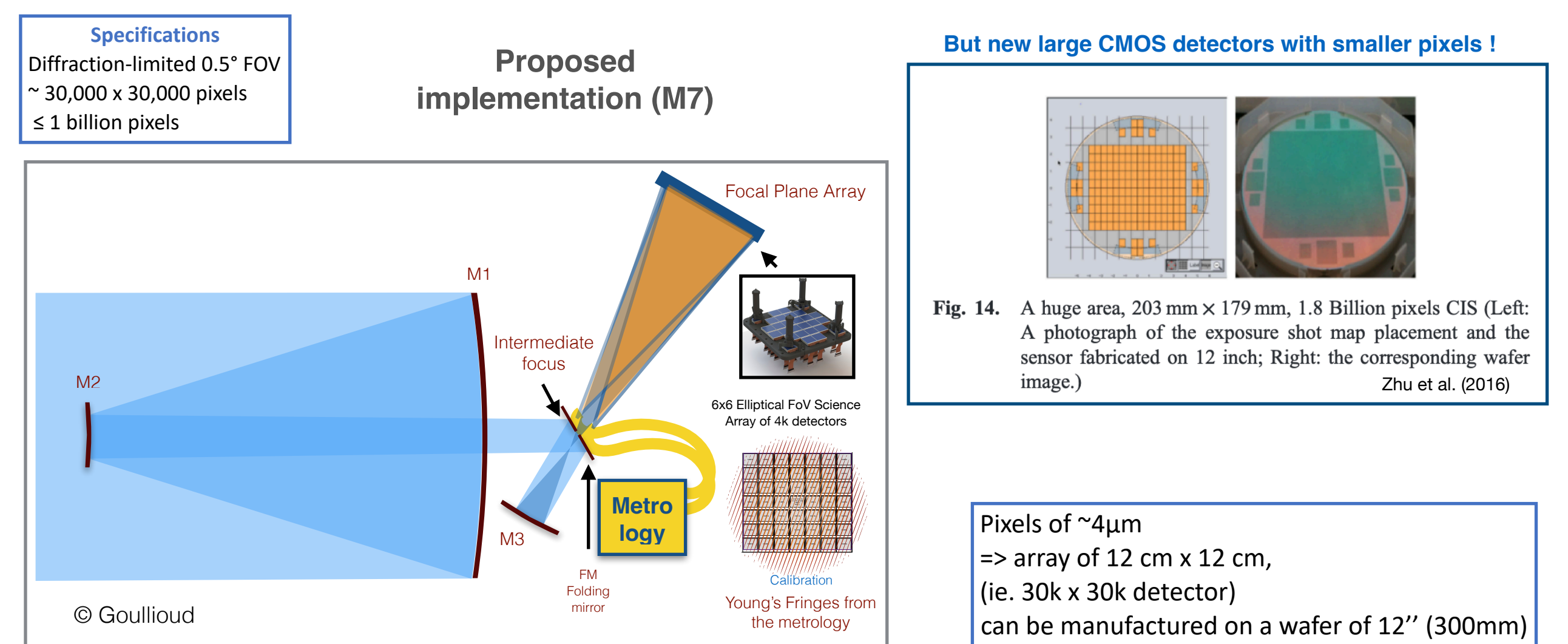


Sun's astrometric position due to activity (1996-2007)



Detection limits have been revisited by Meunier & Lagrange (2023) through a blind test method and found lower detection limits, except for a handful of stars, showing that it is probably possible to reach lower masses.

## Theia instrumental concept



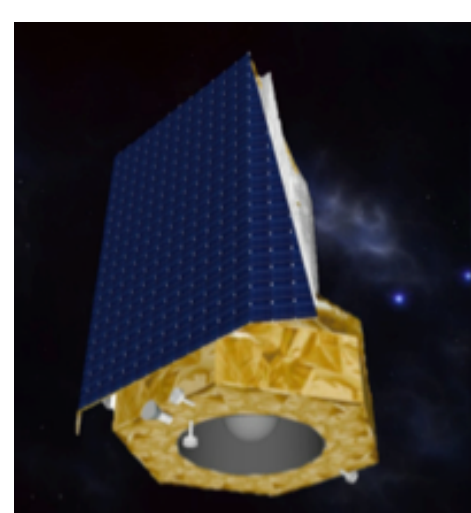
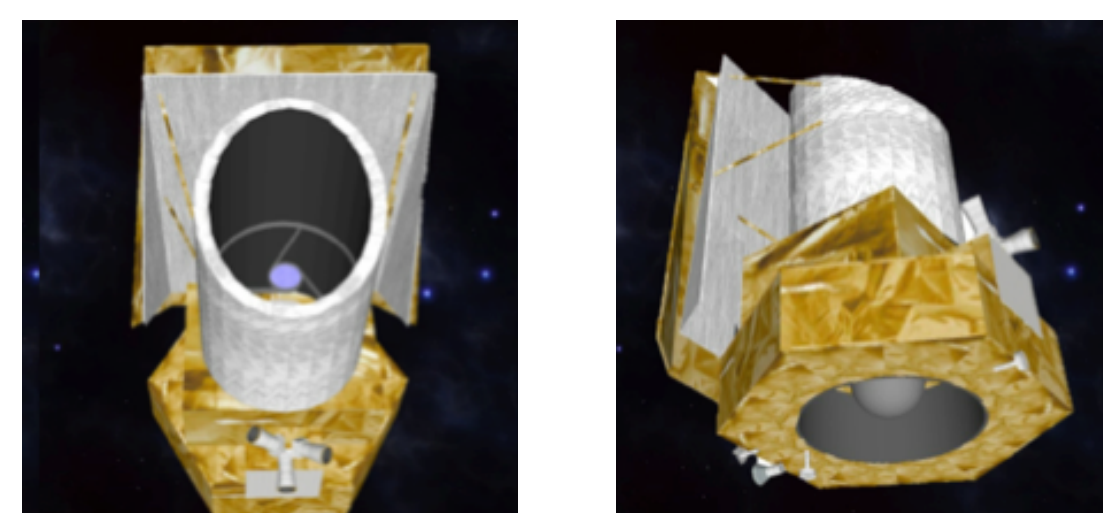
But new large CMOS detectors with smaller pixels!  
Pixels of ~4μm  
=> array of 12 cm x 12 cm, (ie. 30k x 30k detector) can be manufactured on a wafer of 12" (300mm)

## Theia mission profile

- ESA-led, ESA-operated mission with consortium funded payload (this is the normal type of ESA mission)
- Submitted for the ESA M7 call as an Ariane 6.02 launch
- Spacecraft dry mass with margin: 1063 kg. Total launch Mass: 1325 kg



Launch date	No constraints, allowing launch date in 2037
Orbit	Large Lissajous in L2
Lifetime	• 4 years of nominal science operations • Technical operations: 6 months orbit transfer plus instrument commissioning and 1 month decommissioning
Concept	Single spacecraft, single telescope in the PLM, single camera in the focal plane, metrological monitoring of PLM
Communication architecture	75 Mbps, 4hr/day



## Affiliations

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## References

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