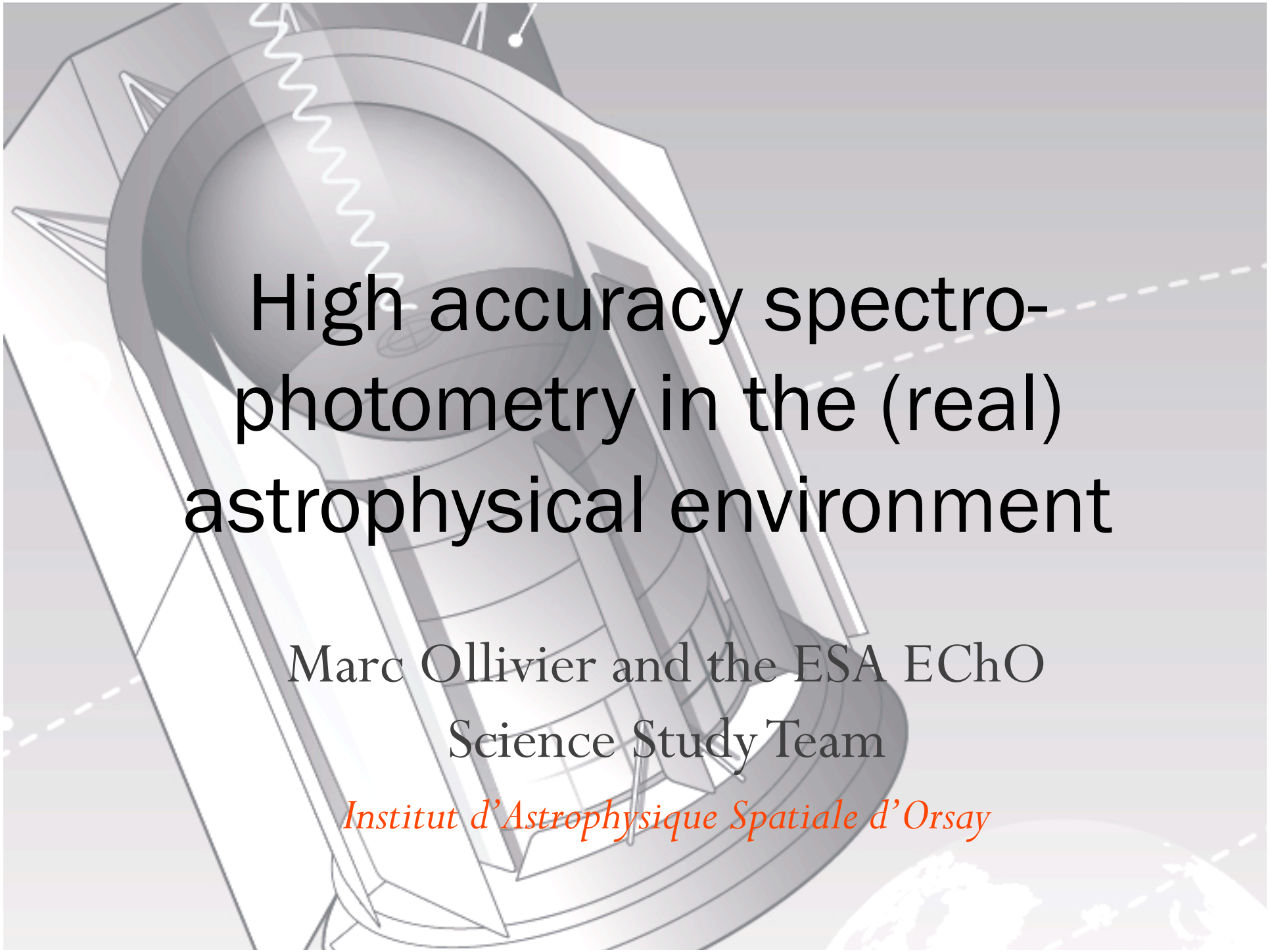


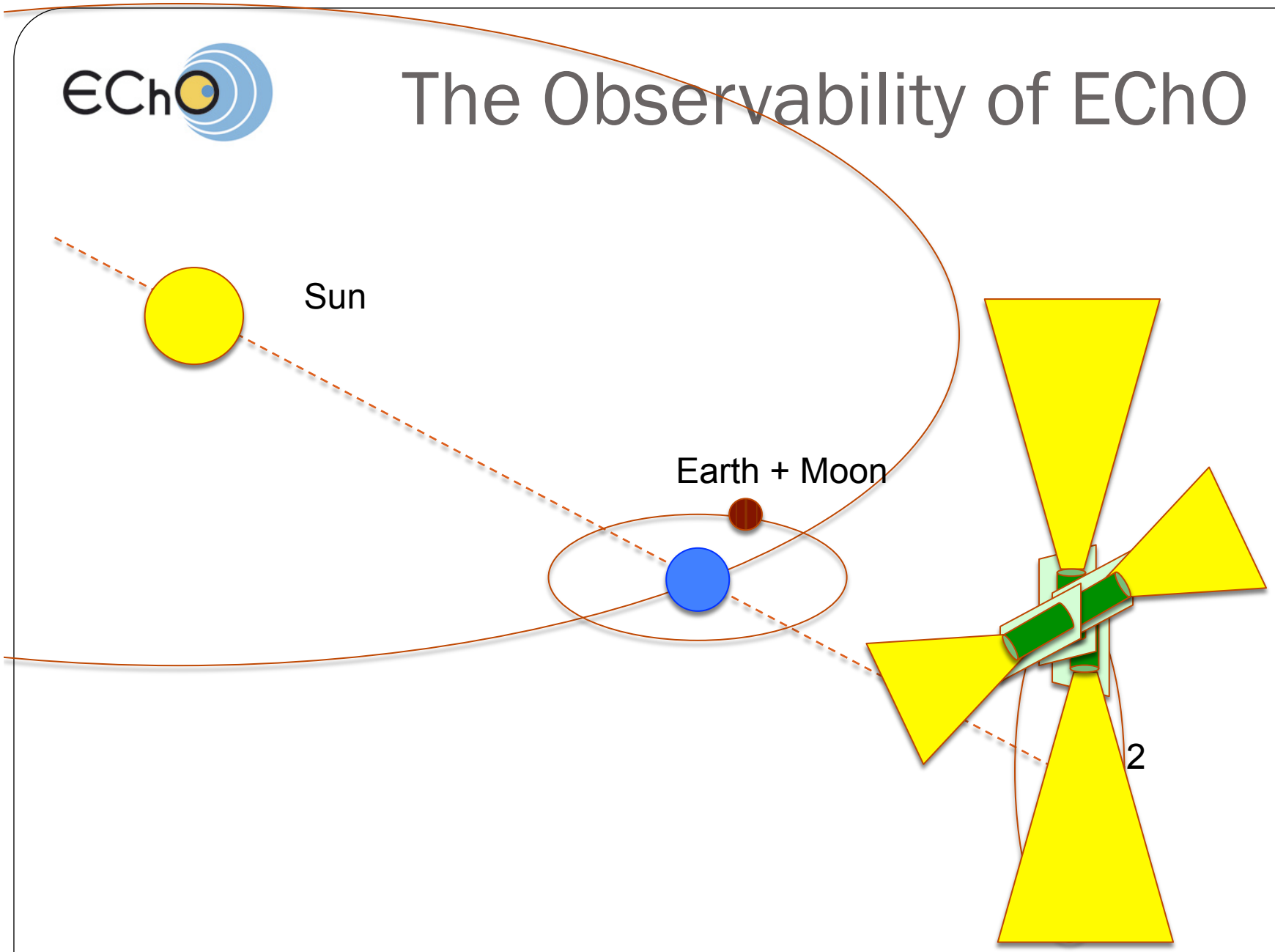
High accuracy spectro-photometry in the (real) astrophysical environment

Marc Ollivier and the ESA EChO Science Study Team

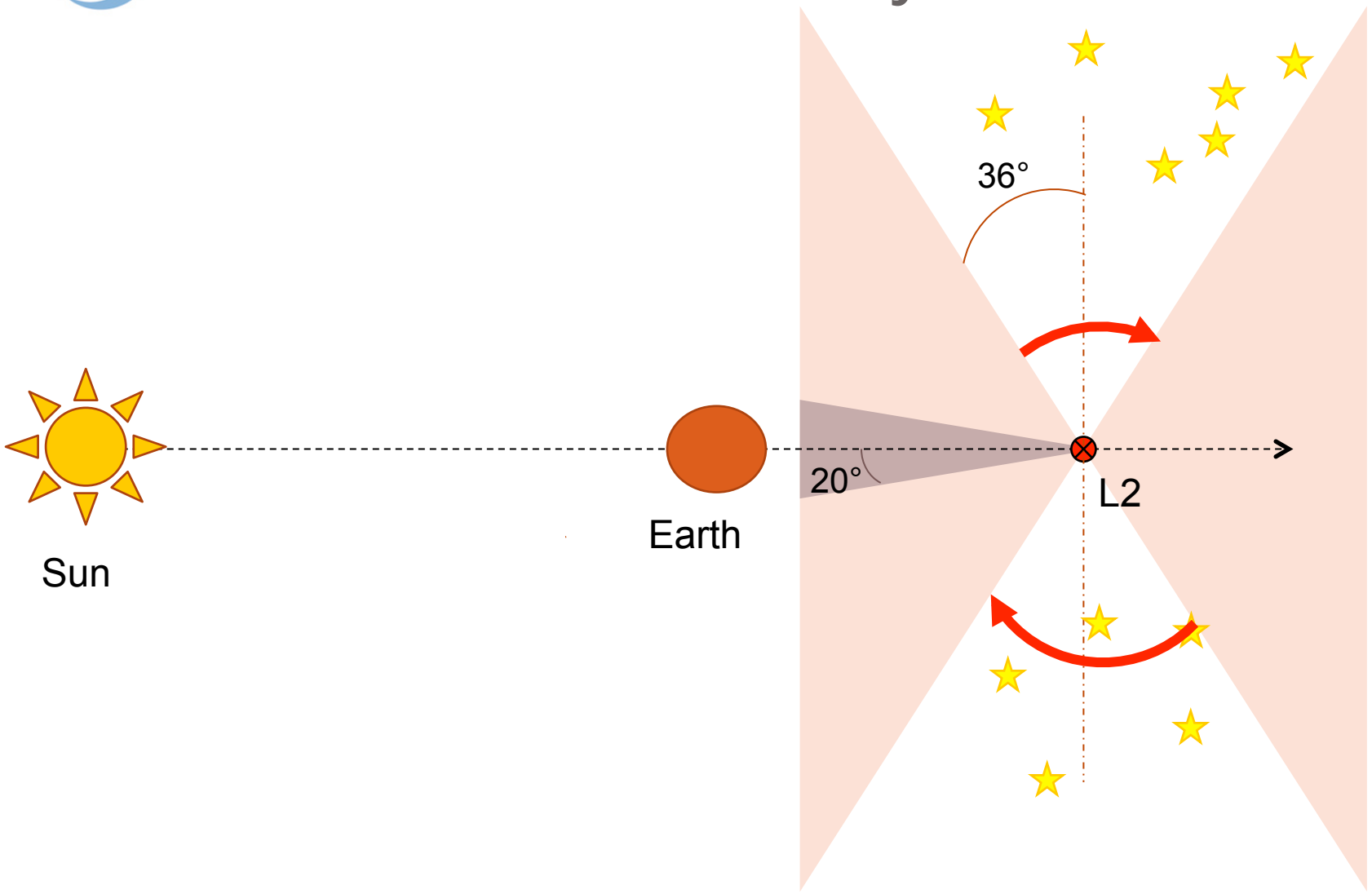
Institut d'Astrophysique Spatiale d'Orsay

I - The observability of EChO

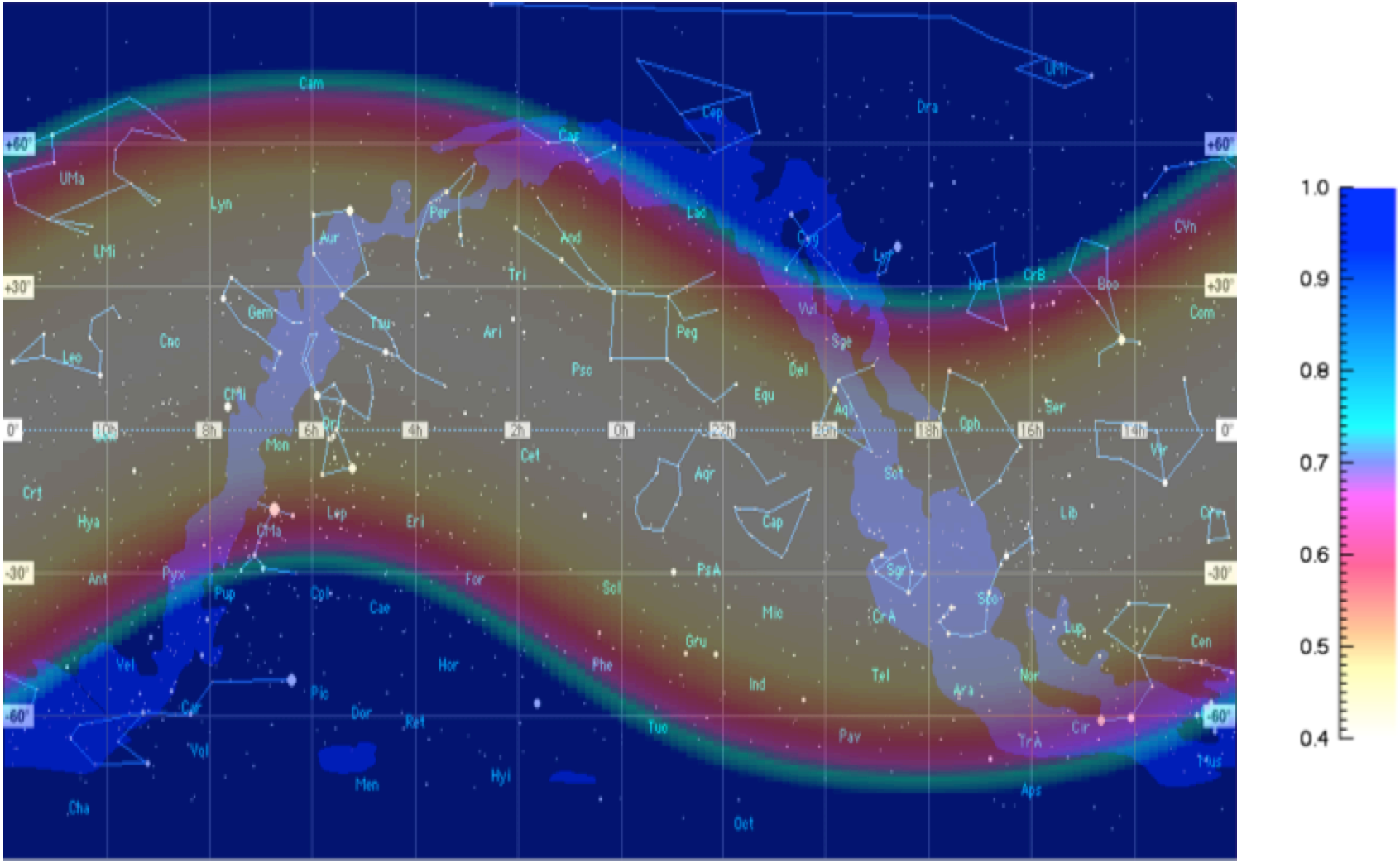
The Observability of EChO



The Observability of EChO



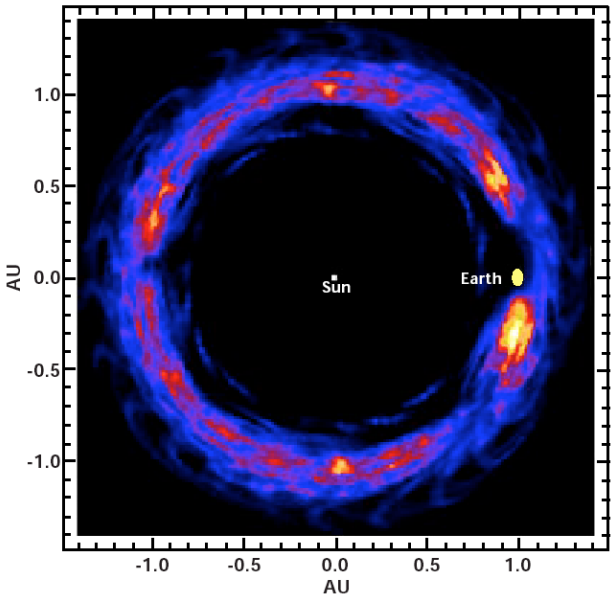
The observability of EChO

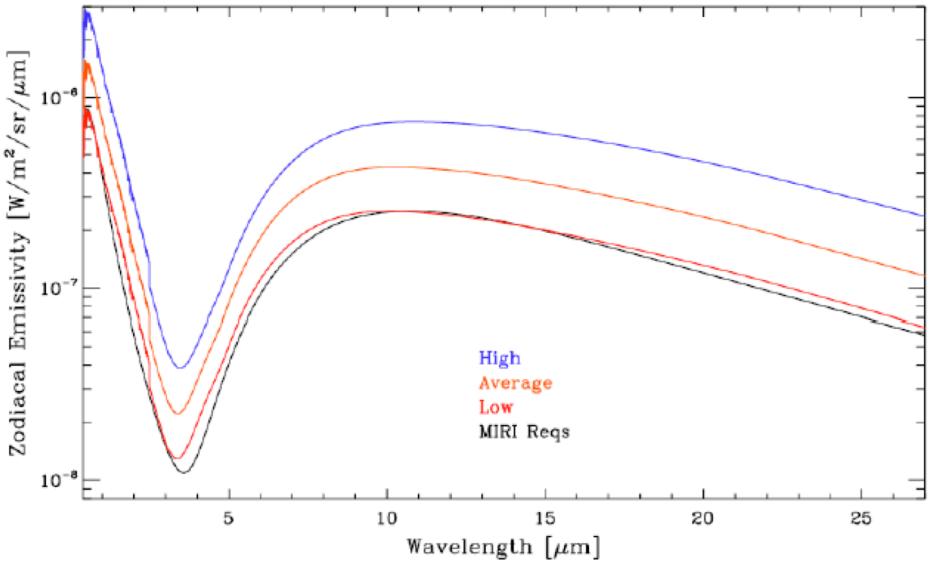


II-- The role of zodiacal clouds

The solar zodi

- Scattering / thermal emission of dust
- Extended le source : variation with the ecliptic latitude
- Extra signal during the detection





$$Zodi(\lambda) = B_\lambda(5500K) \times 3.5 \times 10^{-14} + B_\lambda(270K) \times 3.58 \times 10^{-8} W/m^2/sr/\mu m$$

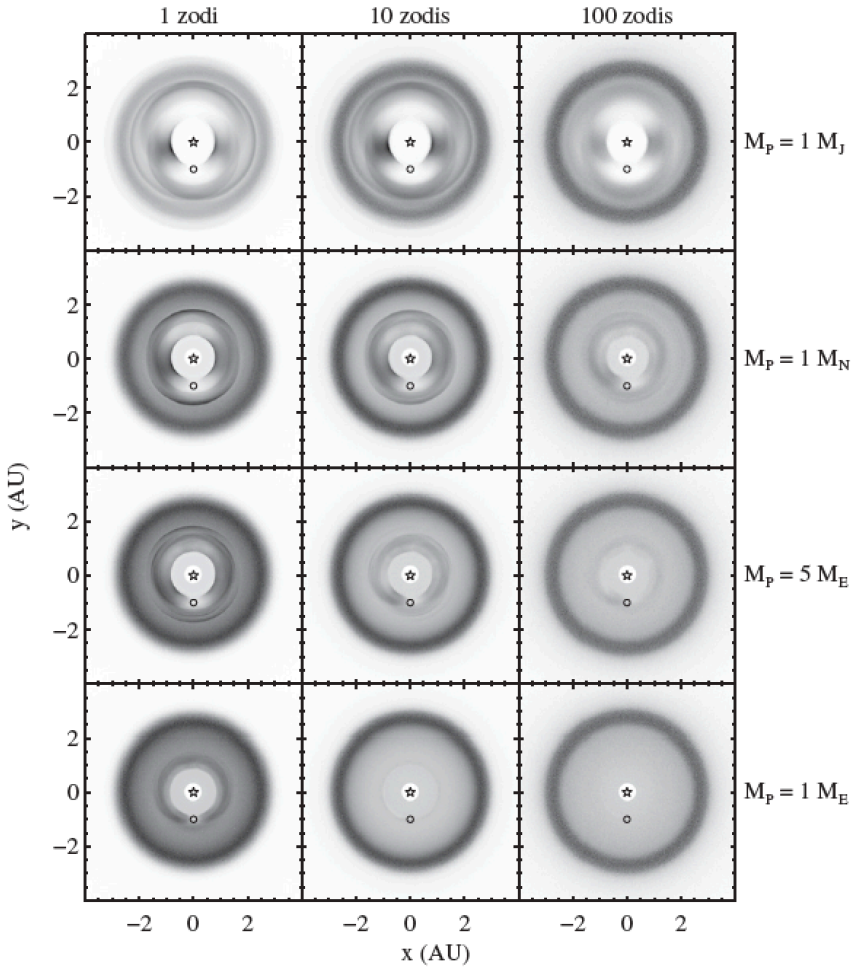
min = 0.9 x zodi(λ), average = 2.5 x zodi(λ), maximum = 8 x zodi(λ)

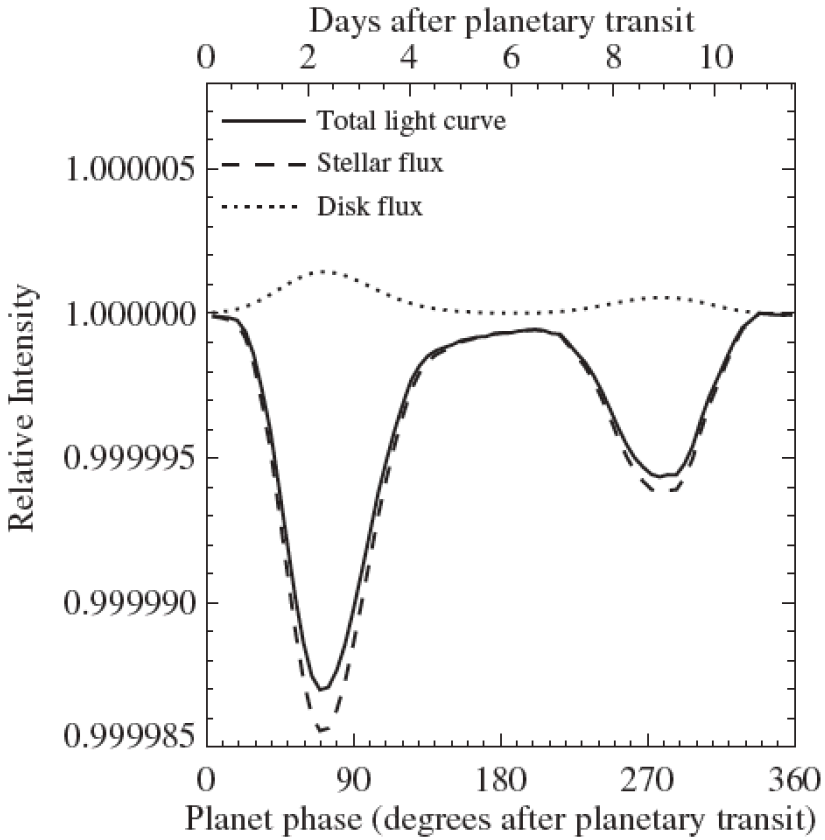
The exoplanet zodi

- Potential dust ring around the target
- Presence of structure due to resonances /interactions with planets
- Disk seen edge-on in the transit / occultation configuration
- Can strongly affect the transit lightcurve of inner planets
  - Vis : transit of structures : spectral signature
  - IR : other variable source of signal + absorption of planetary signal (occultation case)

The exoplanet zodi

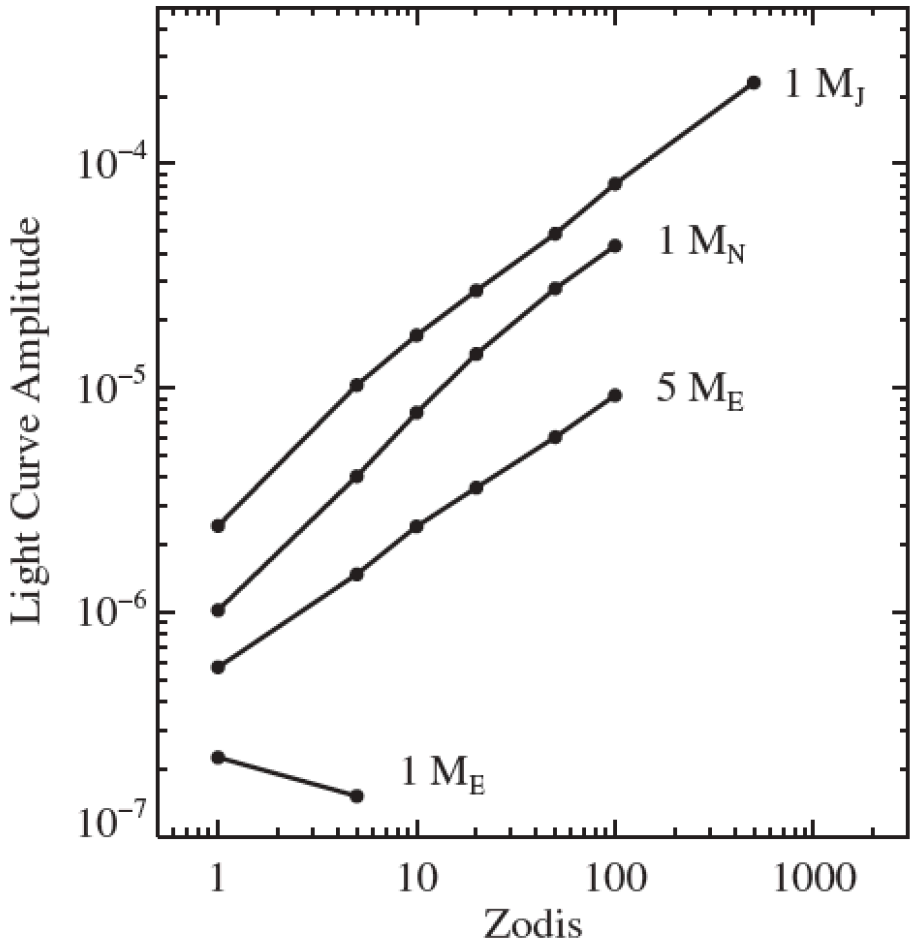
- Visible case studied by Stark (ApJ 142, 123 (2011)





The exoplanet zodi

- Visible case studied by Stark (ApJ 142, 123 (2011)



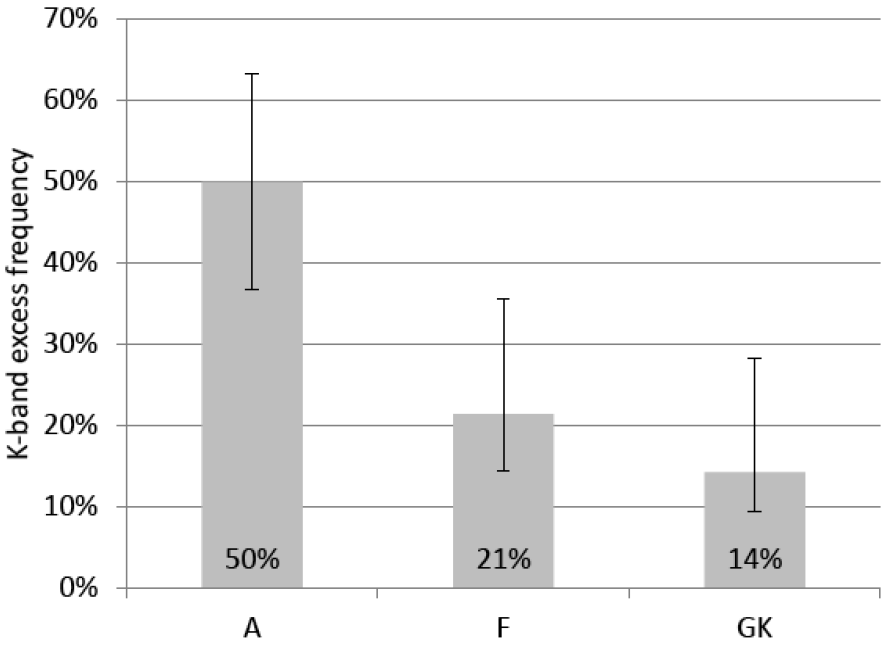
What do we know about exozodis ?

- Detection of exozodi by infrared excess / radius measurements (interferometry)
- Limitation of ground based observations by IR photometry accuracy / sensitivity
- No global exozodi survey

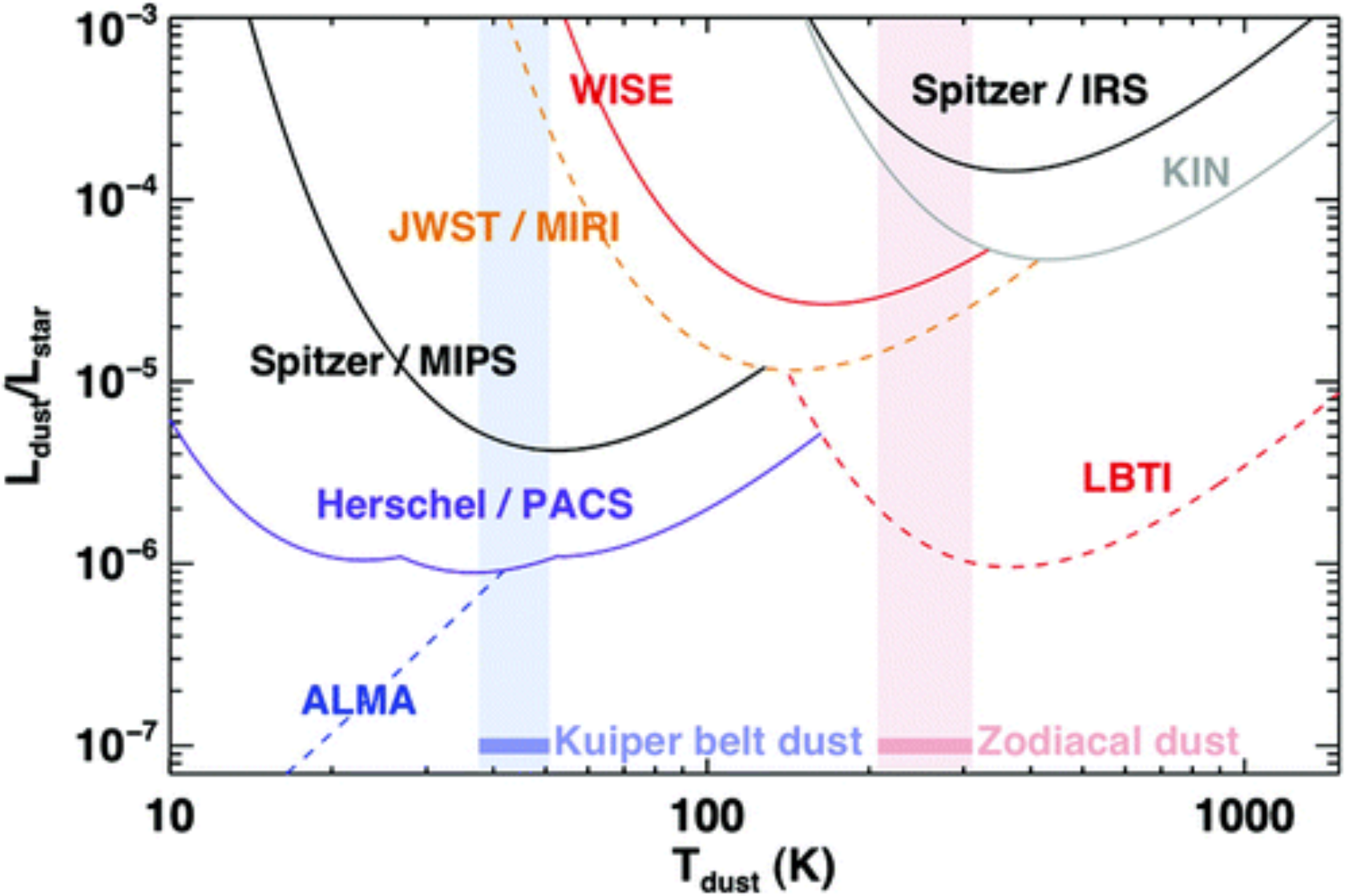
What do we know about exozodis ?

- Absil et al, 2013, submitted to A&A
- Statistics based of a 42 nearby star (biased) sample : detection at the level of 1% of the stellar flux in K band

	A	F	G-K	Total
Outer reservoir	2/7	3/7	1/4	6/18
No outer reservoir	4/5	0/7	1/10	5/22
Total	6/12	3/14	2/14	11/40



How to improve the knowledge of exozodis ?



III – Using the astrophysical environment for calibration

What is the problem ?

- **R-SCI-080:** The EChO instrument and satellite systems shall not induce noise or disturbance in the frequency band of 2.8x105 Hz to 4mHz that raises the fundamental white noise floor in this band by more than 10% following post processing and extraction ofthe wavelength dependent transit signal.
- **R-SCI-190**: An absolute photometric calibration accuracy of 5% (TBC) shall be achieved for all targets across the full waveband of EChOusing celestial objects.
- **R-SCI-193:** Absolute wavelength calibration, after post-processing including calibration observations, shall be accurate to within 1/3 of the required spectral resolution element at all wavelengths and for all targets.
- **R-SCI-194:** The EChO satellite and focal plane instrument shall together provide TBD housekeeping monitoring, calibration sources and reference detector data to allow the coaddition of more than one light curves without increasing the fundamental white noise floor of the measurement by more than 10% in order to obtain the total signal-to-noise ratio required through R-SCI-060. This shall be achieved following frequency dependent signal extraction.

Calibration…

- Detection chain drifts
  - sensitivity to environment (T, cosmic rays, …)
  - Includes effects of many origins (electronics, optics…)
- Detection chain non linearity
  - Sensitivity to illumination level
  - Afterglows…
- Detection chain ageing
  - Loss of sensitivity
  - Increase of noise sources (dark current, readout noise…)

What is the problem ?

- **Need for photometric stability at the level of 10^{-4} (10^{-5})**
- **Need to calibrate all the drifts and biases.**
- **Need to have long time stable references**

- **Difficult to reach with only an internal calibration unit**
- **Idea : using stable stars as long time references**
- **High accuracy photometric measuments of star fluxes CoRoT and Kepler data.**

Stable CoRoT targets

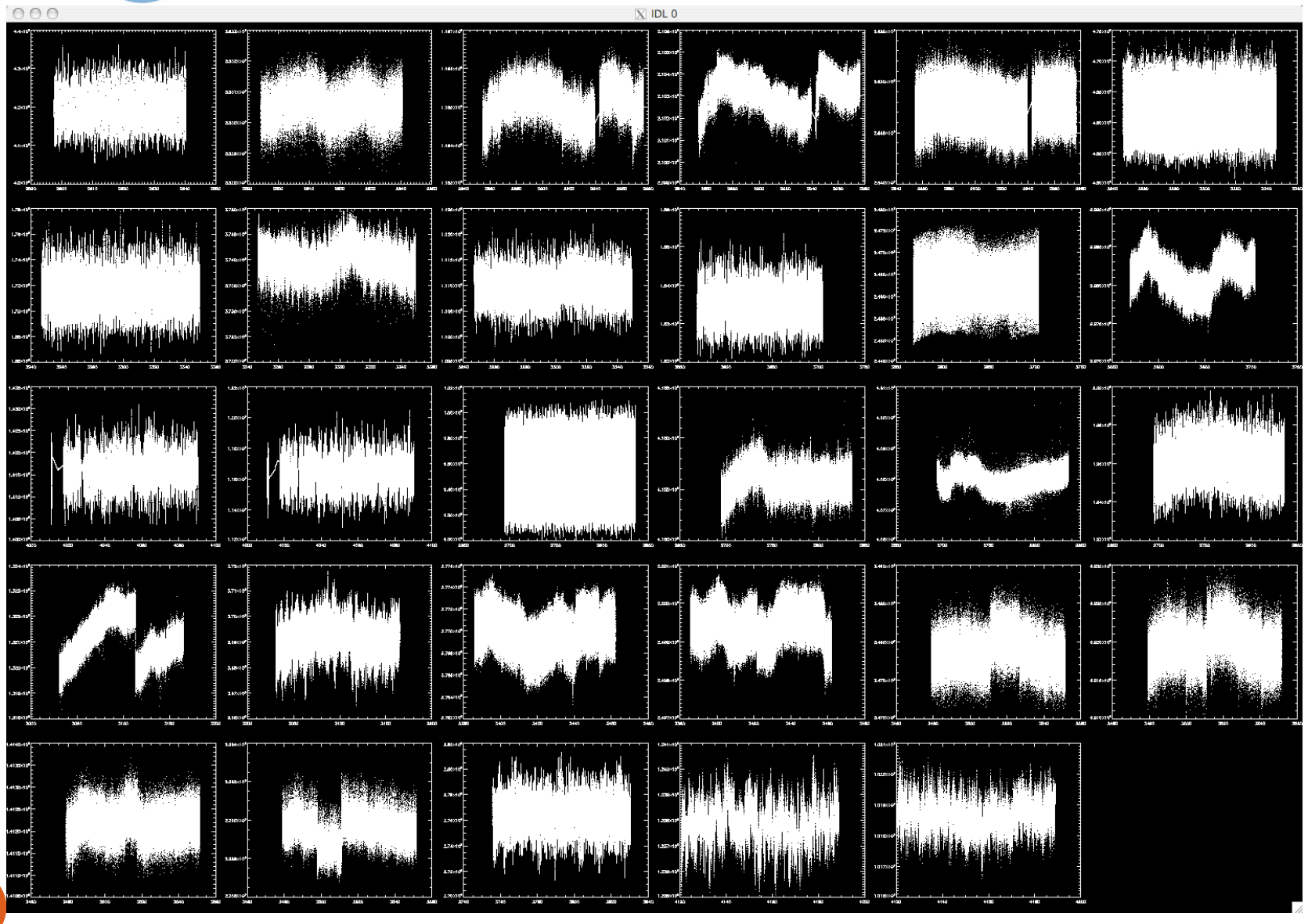
- 29 stars observed in the seismology channel of CoRoT
- $5.7 < mV < 9.3$
- Observation duration : between 55 to 150 days
- Initial sampling rate : 32 s
- Stability measured at 32s, 8.5 min, 1h integration rate as the stellar signal RMS

CoRoT stable stars

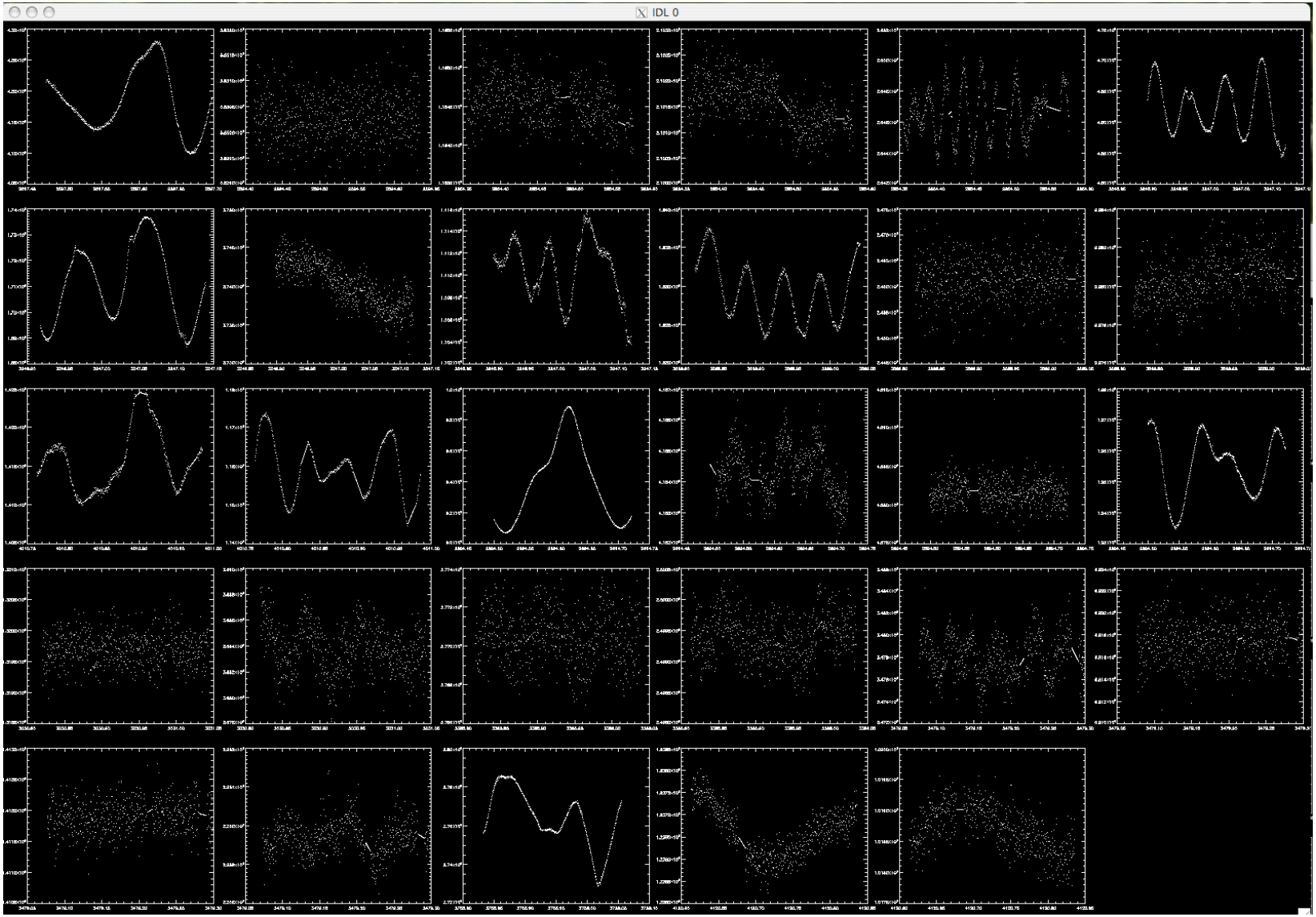
Star CoRoT ID	Observation duration (days)	Relative stability (32 s integration rate)	Relative stability (8.5 min integration rate)	Relative stability (1h integration rate)	Note
123	57.71	1.25e-2	1.25e-2	9.8e-3	
223	56.02	1.26e-4	7.00e-5	6.34e-5	
1	136.33	3.55e-4	3.04e-4	2.95e-4	
18	136.15	3.44e-4	3.14e-4	3.08e-4	1
29	136.89	6.57e-4	5.87e-4	2.89e-4	
546	114.41	9.17e-3	9.00e-3	3.57e-3	
1022	117.37	9.09e-3	9.03e-3	6.87e-3	
1098	117.41	7.09e-4	6.11e-4	5.92e-4	
1320	117,41	2.73e-3	2.69e-3	1.90e-3	
3072	150.41	2.70e-3	2.67e-3	2.15e-3	
3093	145.56	1.42e-3	3.54e-4	2.84e-4	
3474	145.78	1.98e-4	1.79e-4	1.75e-4	
4977	94.43	2.58e-3	2.56e-3	2.20e-3	
5685	94.43	8.44e-3	8.32e-3	4.48e-3	
8393	156.65	2.71e-2	2.70e-2	2.46e-2	
8481	153.69	2.83e-4	2.61e-4	2.43e-4	
8527	153.68	5.59e-4	4.58e-4	4.51e-4	
8669	156.65	4.87e-3	4.82e-3	3.28e-3	
8394	83.83	2.94e-4	2.34e-4	2.26e-4	2
8441	149.01	1.6e-3	1.56e-3	1.48e-3	
9071	84.56	4.11e-4	2.74e-4	2.50e-4	
9161	80.11	1.65e-4	1.12e-4	1.10e-4	
9378	87.21	6.01e-4	4.83e-4	3.89e-4	
9436	87.21	3.17e-4	1.97e-4	1.86e-4	3
9775	82.03	2.10e-4	1.17e-4	1.06e-4	
9861	46.47	2.27e-4	1.53e-4	1.25e-4	4
8301	89.28	5.21e-3	5.19e-3	4.24e-3	
8852	83.07	5.91e-4	5.63e-4	5.54e-4	
8943	83.07	4.51e-4	3.91e-4	3.80e-4	

[1.3] : an uncorrected temperature jump remains
[2] : only the first part of the light curve, before an uncorrected temperature jump
[4] : only the second part of the light curve, after an uncorrected temperature jump

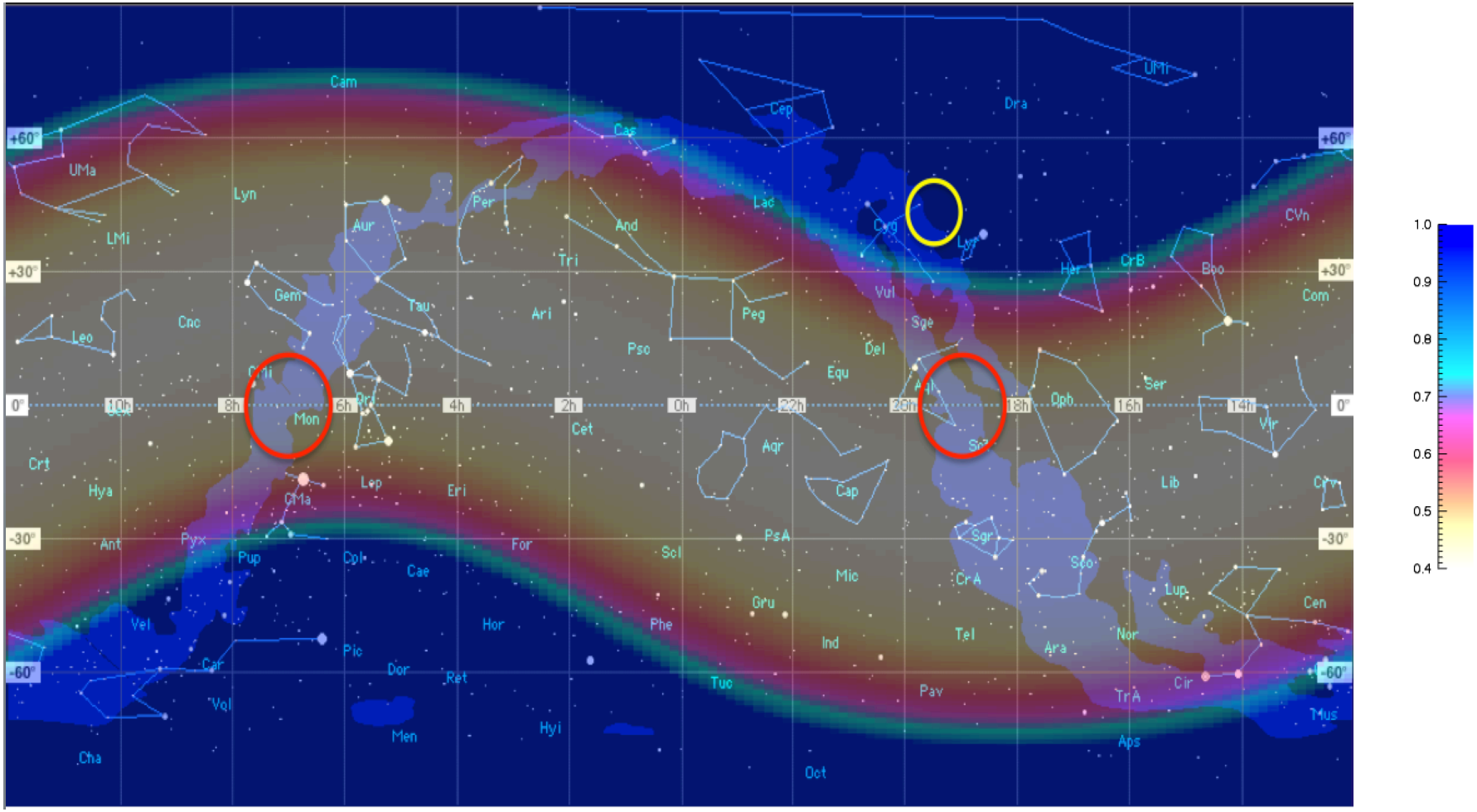
CoRoT stable stars



CoRoT stable stars



Calibrations stars



Calibration on (other) stable stars

- Sciardi et al (2011) : 70 % of G stars are stable at 10^{-5} level
- Distributed all over the sky
- Strategy to identify them cf. Beaulieu's talk

Conclusions

- The astrophysical environment is a large source of contamination (at the level of EChO accuracy)
- Preliminary science / observations should be done to characterize each EChO target before launch
- The required facilities exist
- The environment can be used as calibration for instrumental drifts and biaises.