

# **EXTRASOLAR PLANETS FROM DOME -C**

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**Detecting extrasolar planets  
Transit & Microlensing**

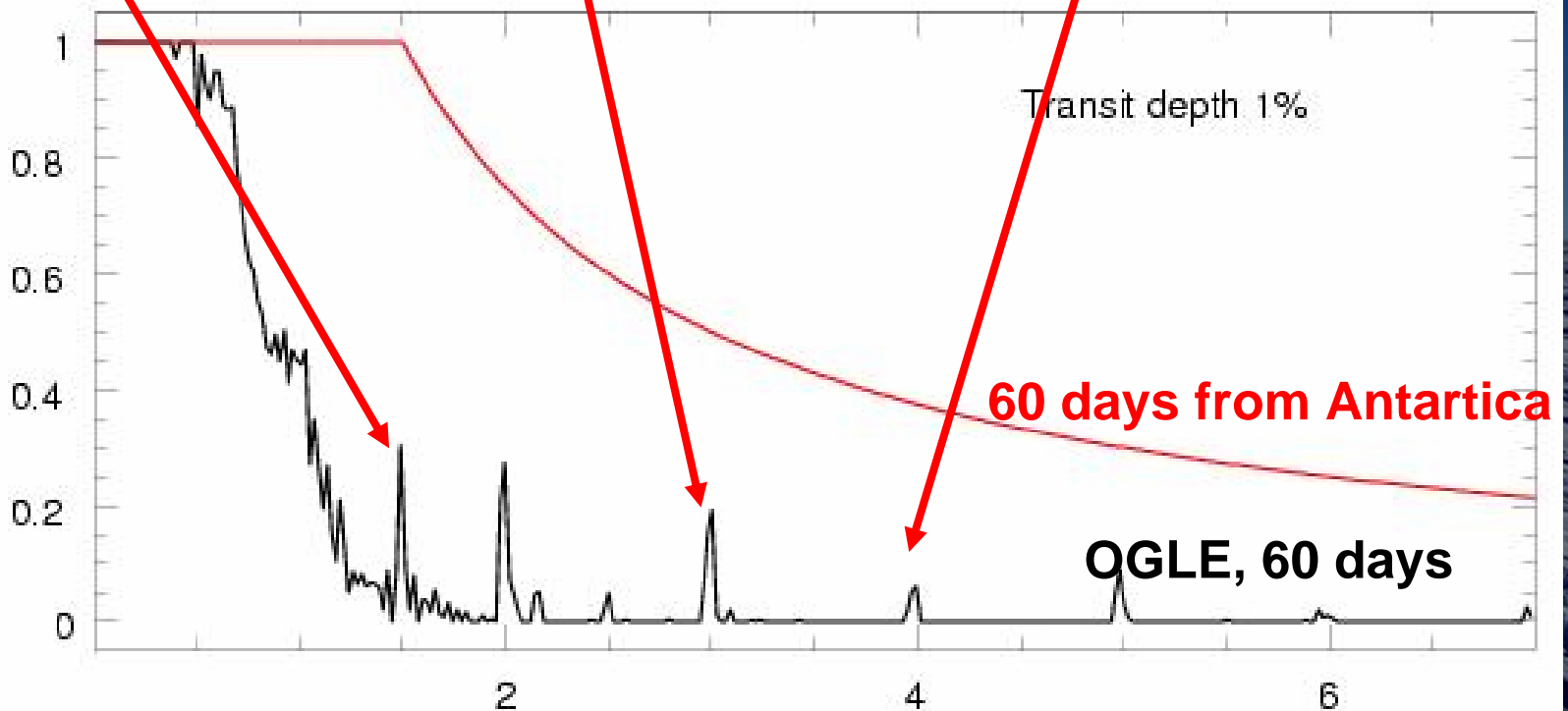
**Characterizing extrasolair planets  
Transit**

# Transit : time coverage

OGLE-56b [1.21 d]  
OGLE-113b [1.43 d]  
OGLE-132b [1.69 d]

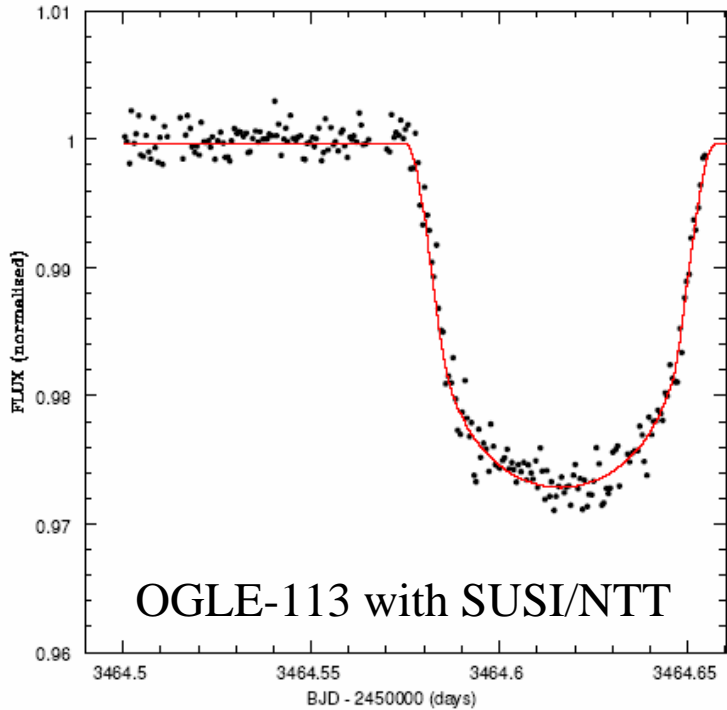
Tres-1 [3.03 d]  
OGLE-10b [3.10 d]

Xo-1 [3.94 d]  
OGLE-111b [4.02 d]

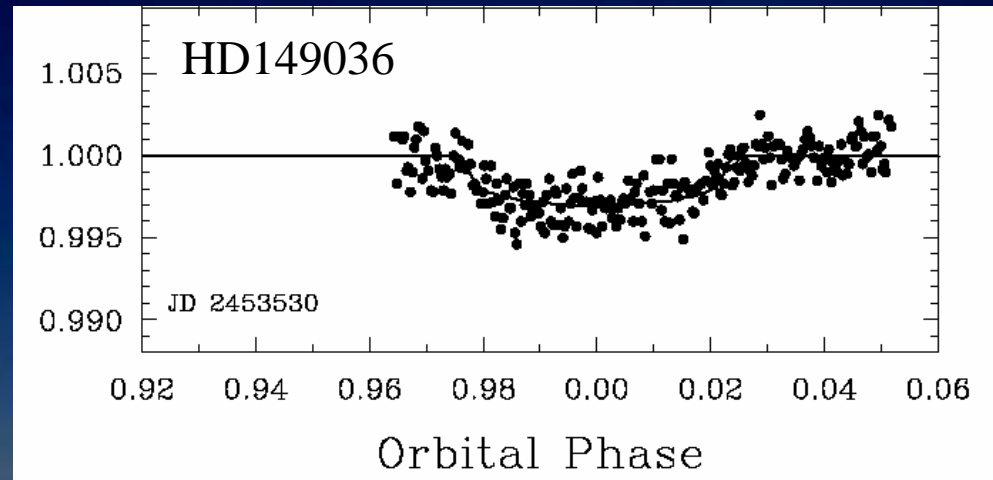


Most abundant Hot Jupiters  
[3-4 d]

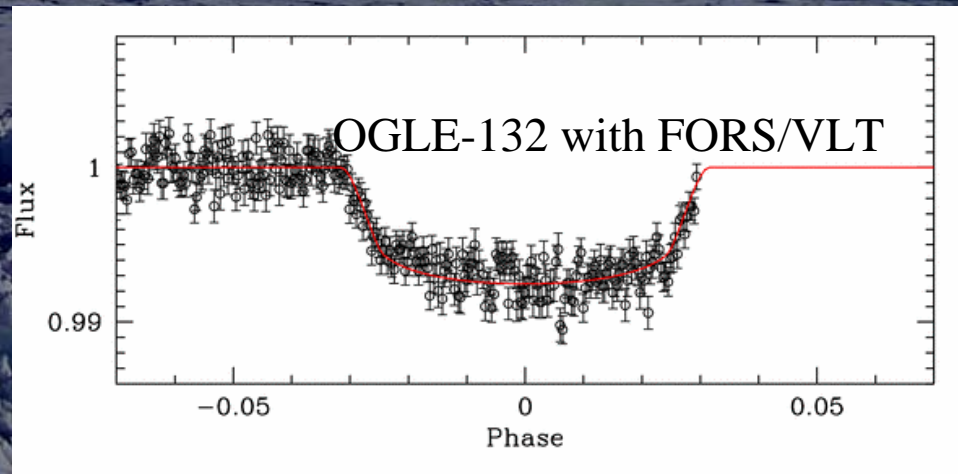
# millimag precision is possible from ground



*Gillon et al.*



*Sato et al. (2005)*

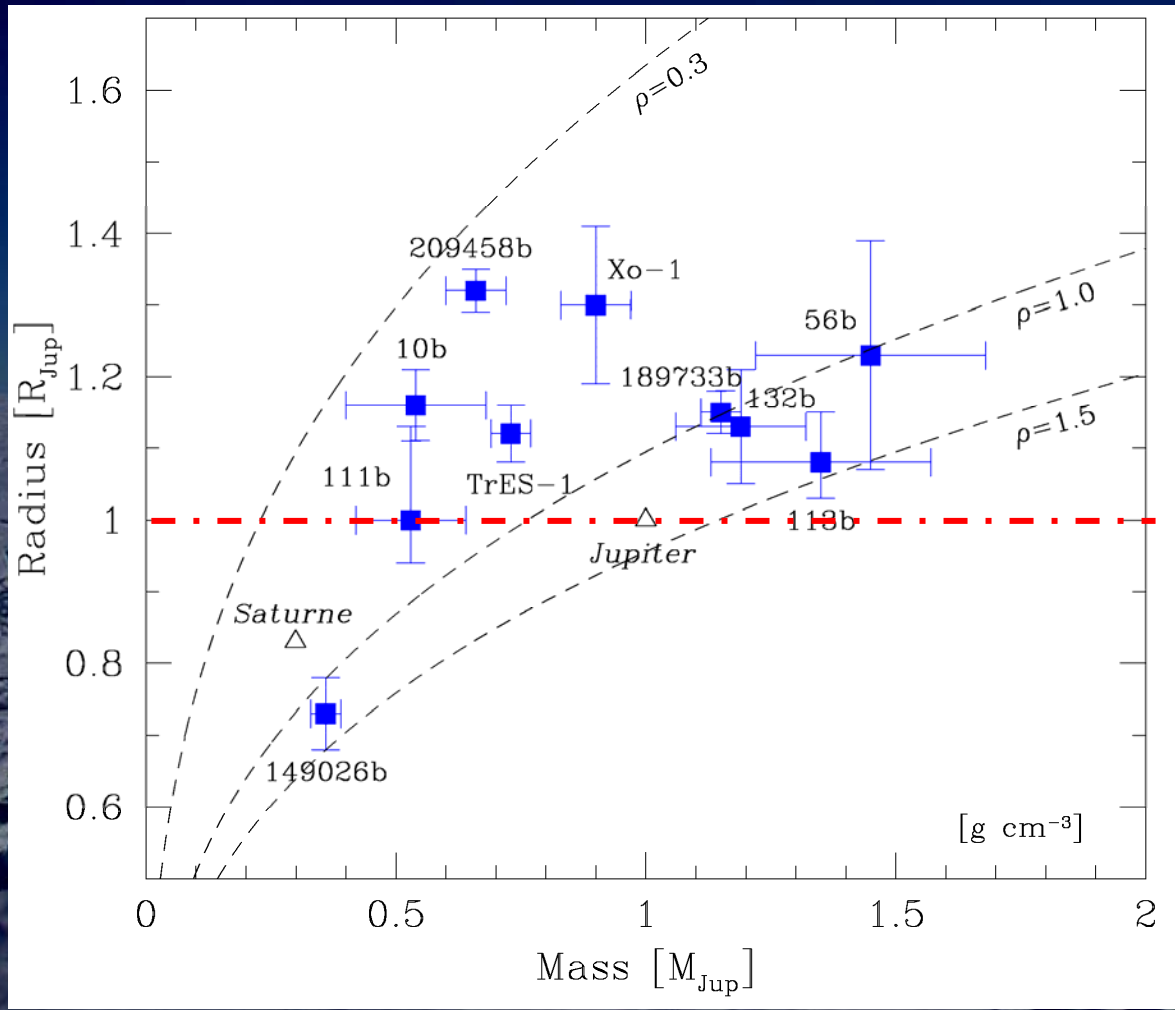


*Moutou et al. (2004)*

Of course, low scintillation, stable seeing would help...

**Do not underestimate red noise (correlated noises) !**

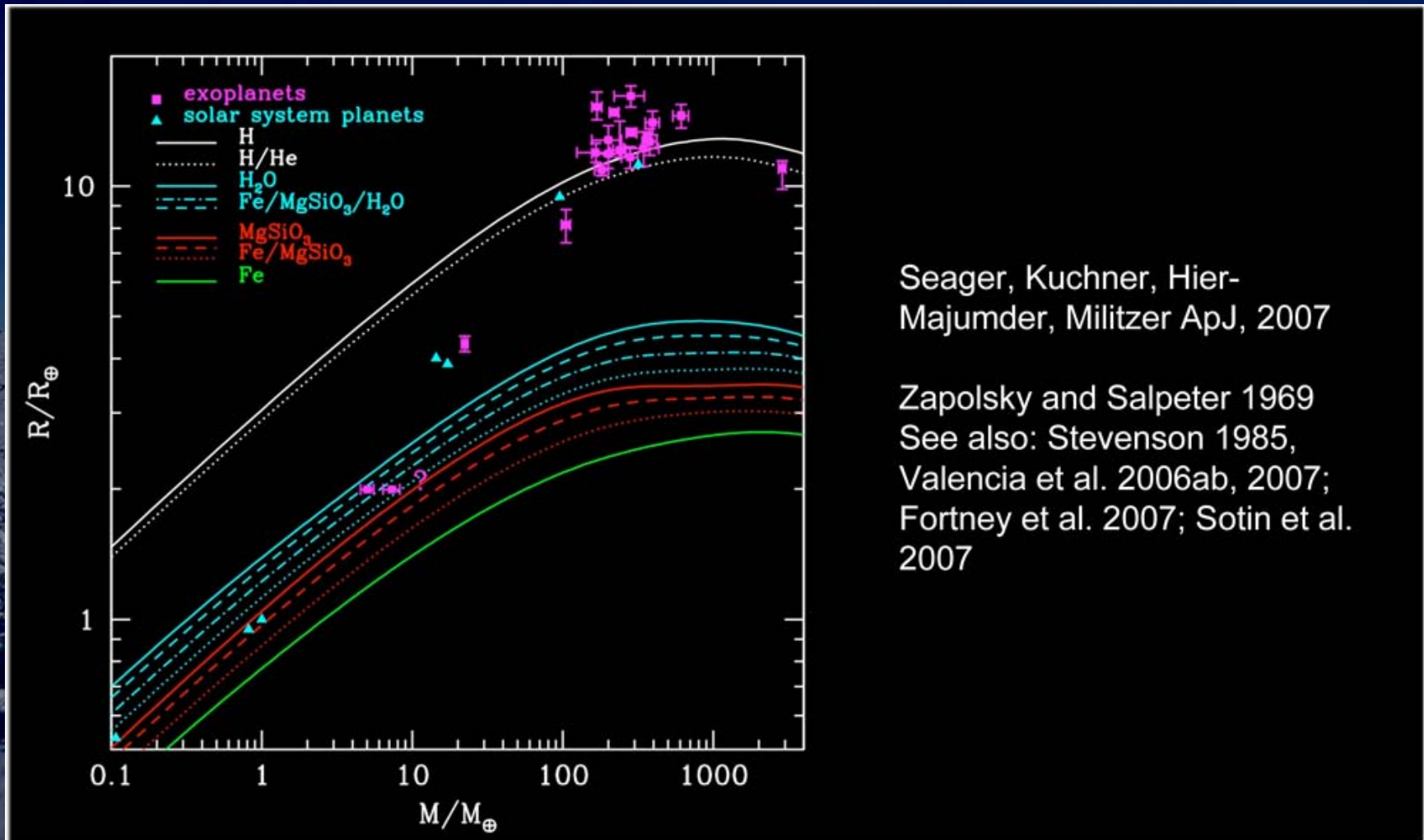
# Transit+VR = Mass Radius relations



## Transit Depth

OGLE-113	2.9%
Tres-1	2.3%
Xo-1	2.0%
OGLE-111	1.9%
OGLE-10	1.9%
OGLE-56	1.3 %
OGLE-132	1.1 %

# Mass – Radius relation



Information about the structure of the planets !

# TRANSIT SEARCHES

**Need to search bright transit :**

- **Lower part of Mass Radius relation**
- **Getting good candidates to probe planetary atmosphere**
- **We need the planets transiting the bright stars !**

Wide field search, good duty cycle, stable photometric conditions

Optical ? Near IR ?

A small (<1m) telescope quickly ?

A wide field imager 2012+ on small (~1m), or larger (2m class) ?

A superwide imager (several small telescopes to monitor all bright stars) 2012+ ?

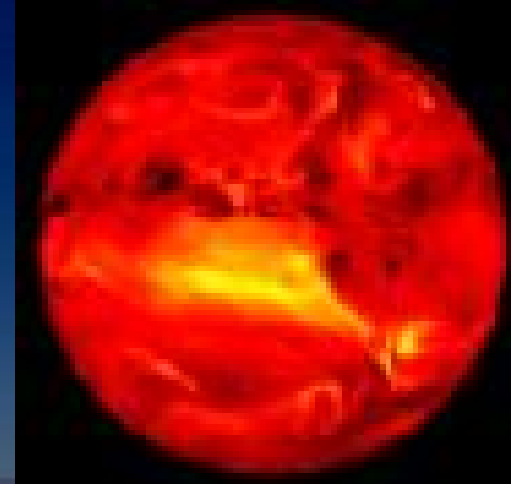
**Can we detect ~10 Earth mass planets by transit from the ground ?**

**Is it useful in the post COROT/KEPLER era ?**

**What are the competing projects at the horizon 2010+ ?**

# Probing extrasolar planet atmospheres

*Following G. Tinetti's talk*



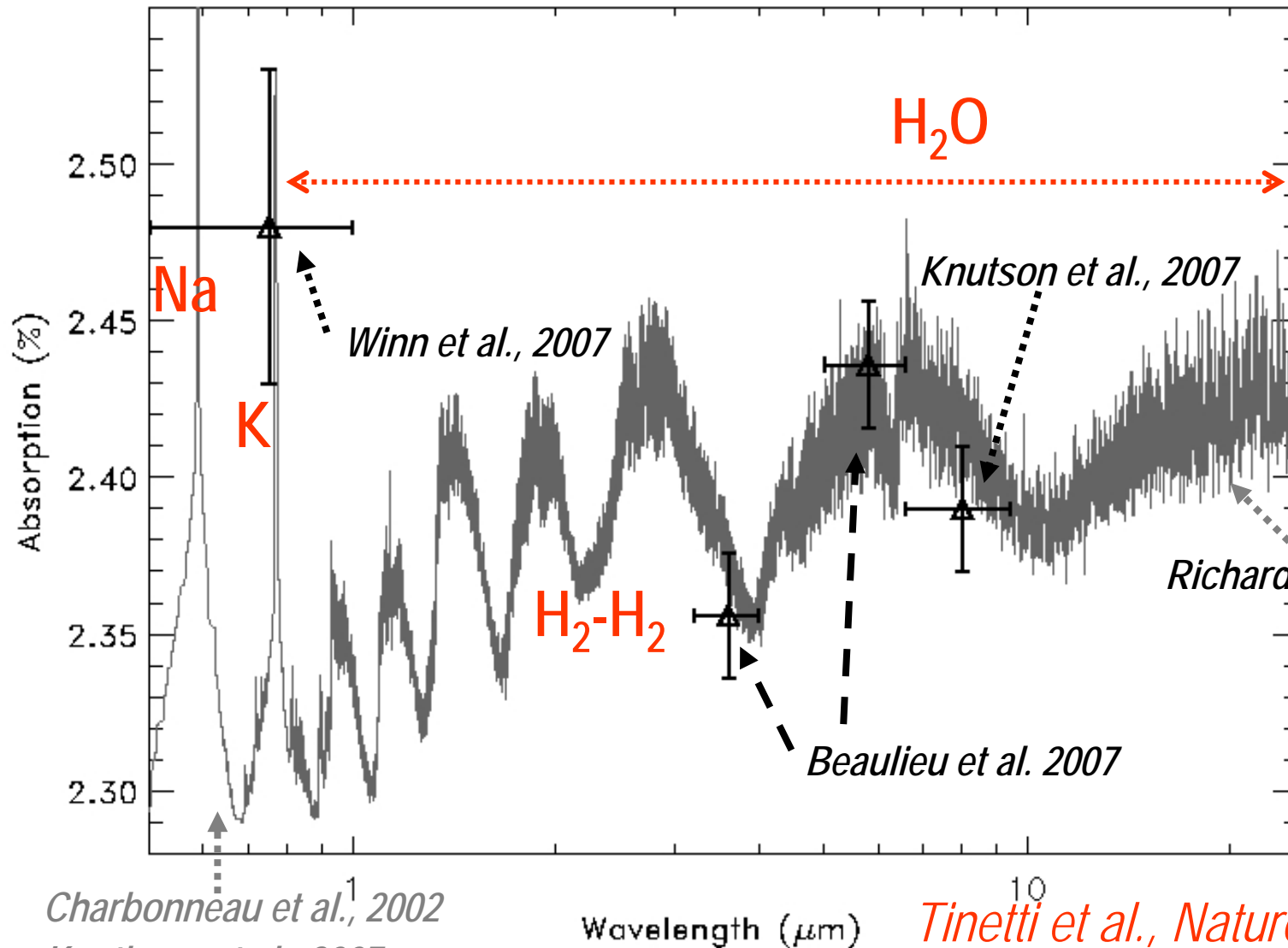
- **Primary transit :**
  - Measure size of transiting planet
  - see radiation from star transmitted through planet's atmosphere
  - hot jupiters, Neptunes, Super Earth
- **Secondary transit :**
  - Thermal radiation from planet disappear and reappear
  - Estimate eccentricity of orbit

# The observing challenge

- **Transit**  $[R_p/R_*]^2 \sim 10^{-2}$
- **Emission spectra**  $T_p/T_* [R_p/R_*]^2 \sim 10^{-3}$ 
  - Emitting atmosphere  $\tau \sim 1$
  - Temperature and temperature gradient
- **Transmission spectra**  $\text{atm}/R_*^2 \sim 10^{-4}$ 
  - Upper atmosphere
  - Exosphere
- **Scattered light spectra**  $p [R_p/a]^2 \sim 10^{-5}$

Albedo, phase curve, scattering atmosphere, polarisation

# Transmission spectrum from the VIS to the far-IR



Abs. coeff.:  
(Allard N., 2006;  
Barber 2006;  
Borisow et al., )

T-P profile  
Iro et al., 2005  
Burrows et al., 20

Richardson et al., 2006

Charbonneau et al., 2002  
Knutson et al., 2007a

Tinetti et al., Nature 448, 163

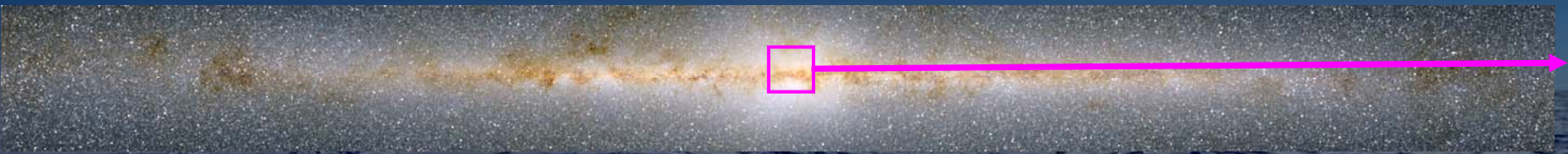
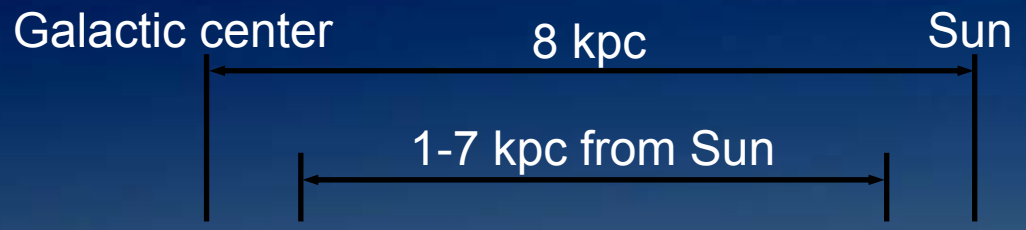
- Questions :
  - What is the minimal size of telescope ?
  - What is the needed resolution to distangle Earth and target atmospheres ?
- Science driver monitoring of transiting planets  
(primary and secondary eclipses).



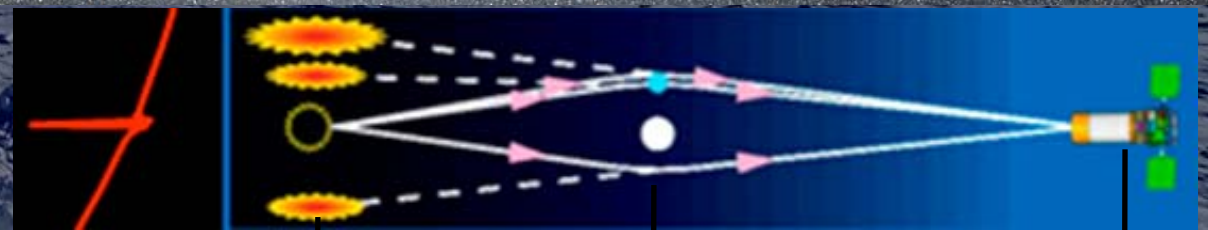
• Swain (JPL), Patrick Little (Mudd college)

# Microlensing in the Central Galactic Bulge

Monitor ~100 millions stars



Light curve



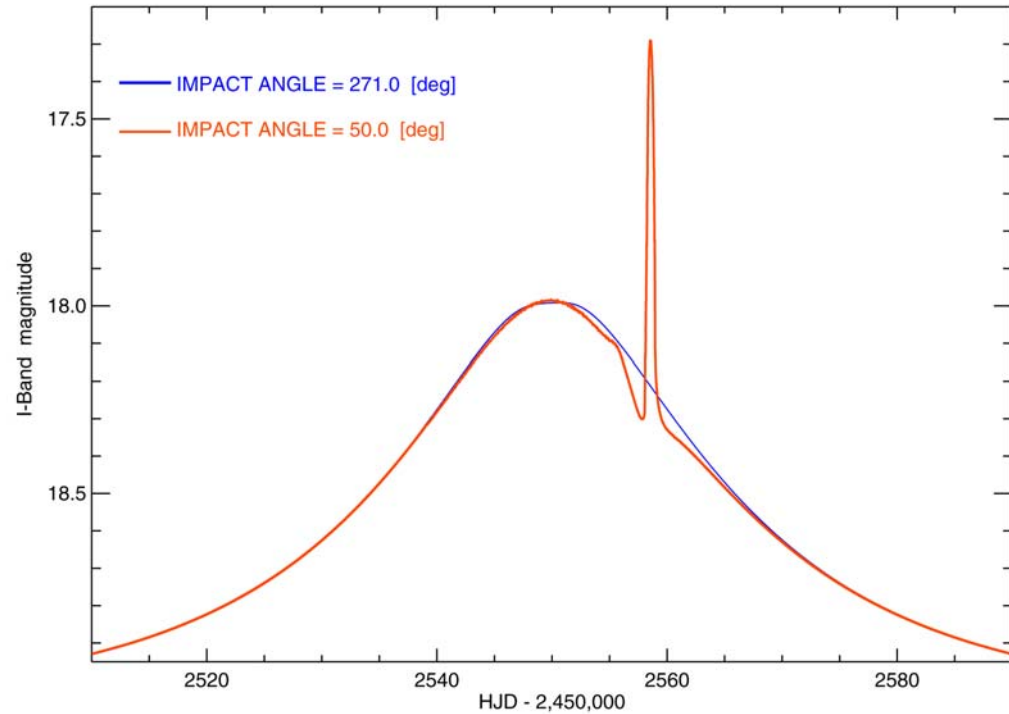
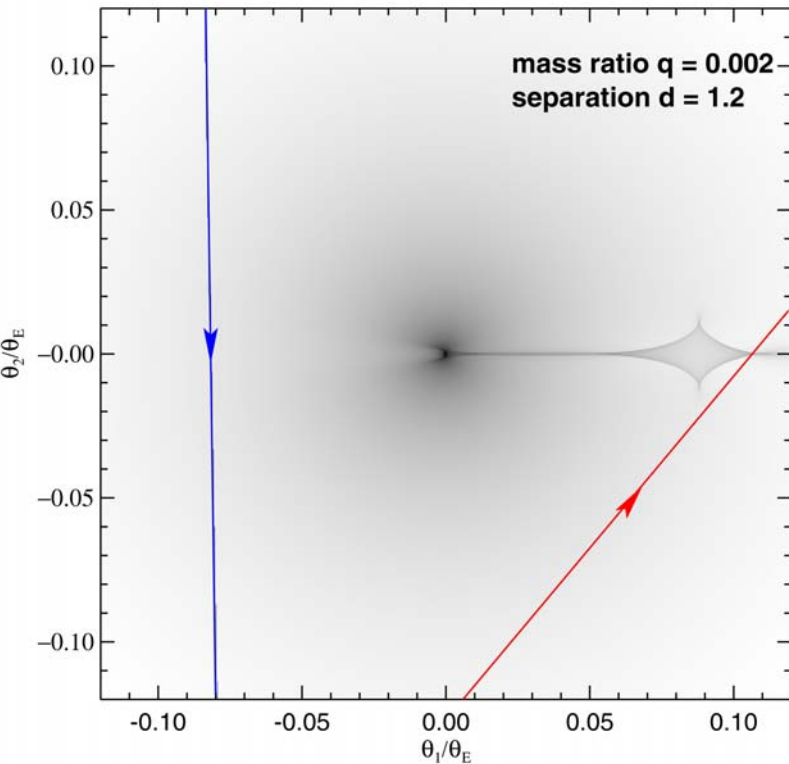
Source star and images

Lens star and planet

Observer

**Monitor several fields toward the Galactic bulge in order to detect planetary companions to stars in the Galactic disk and bulge. These planets will be found using gravitational microlensing.**

# DETECTING PLANETARY COMPANION



$$t_p = \sqrt{q} t_E$$

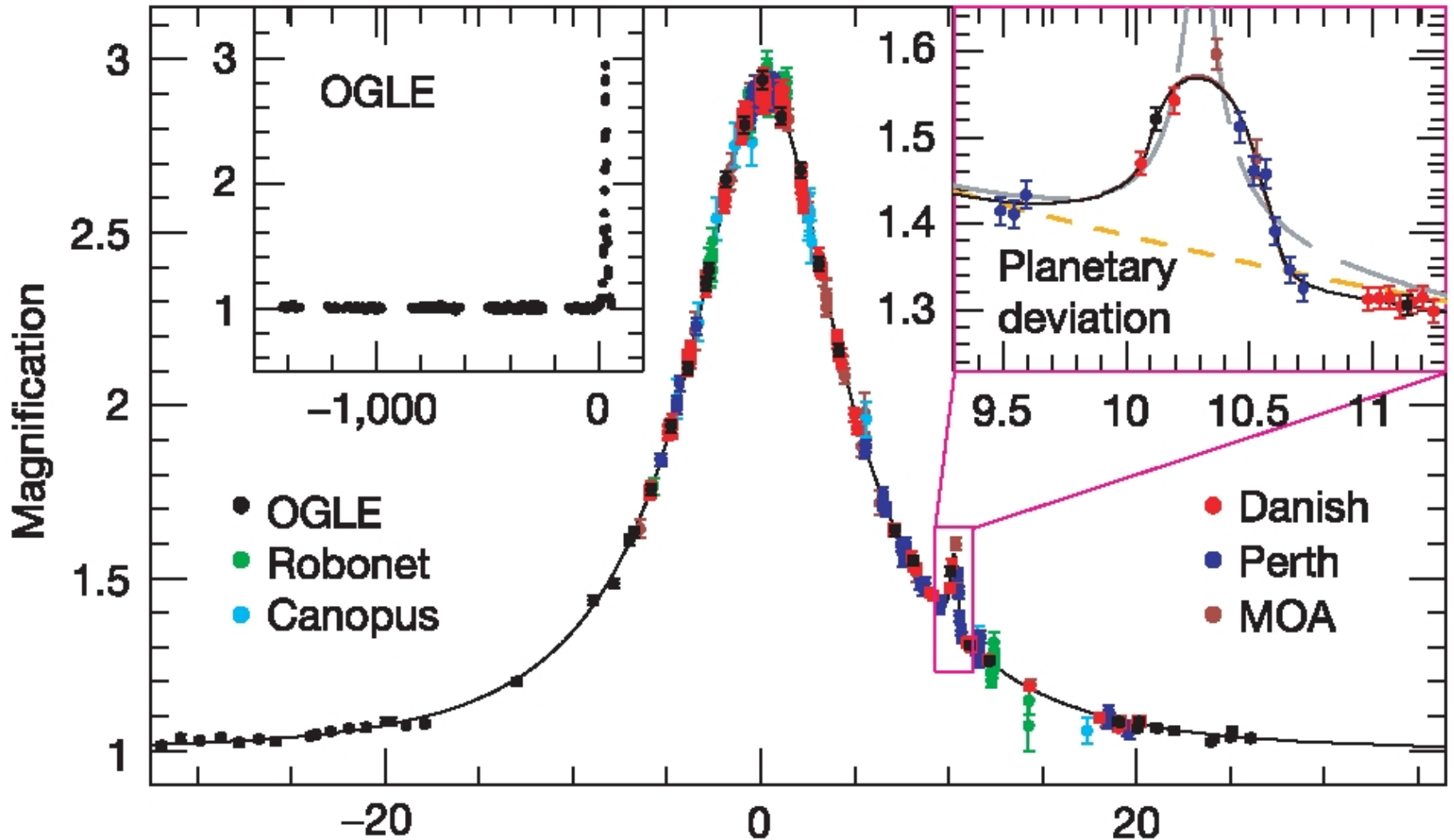
$$t_E = 20 \text{ j}, M = 0.3 M_{\text{sun}} :$$

$$\text{Jupiter} : q = 310^{-3} \Rightarrow t_p = 1 \text{ d}$$

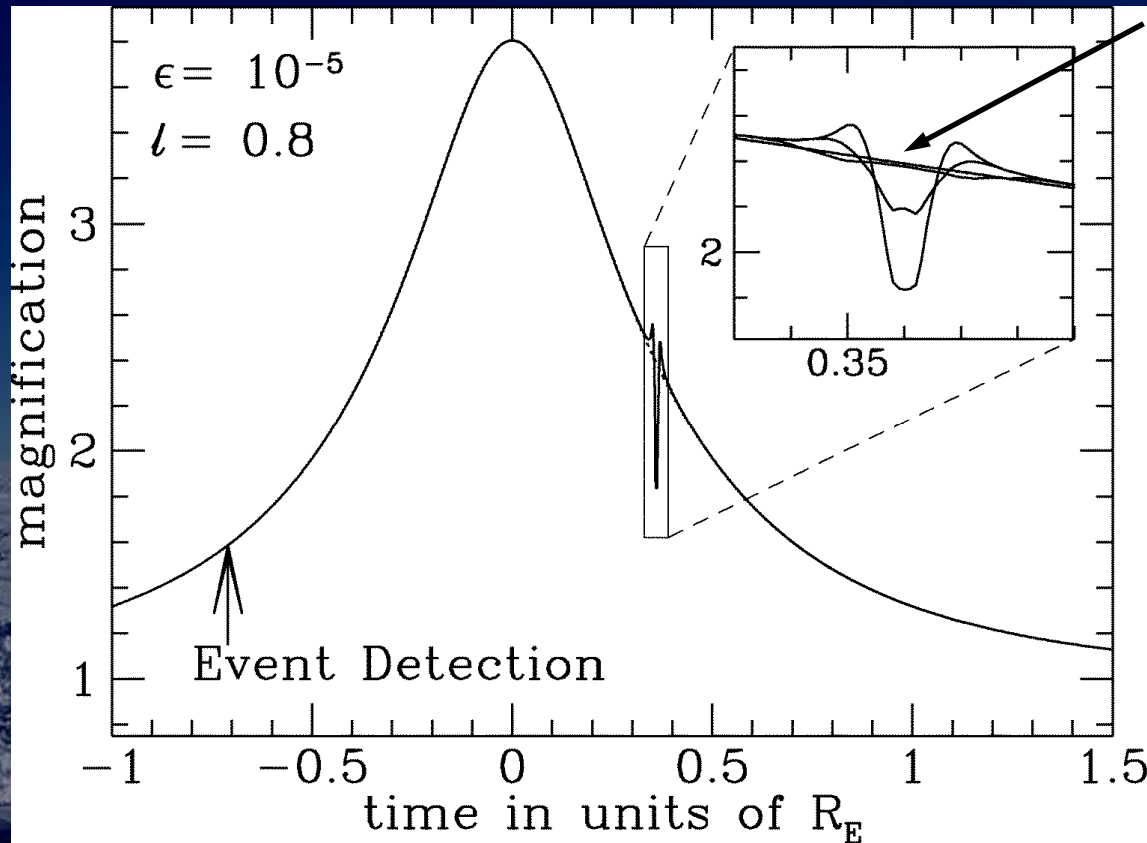
$$\text{Earth} : q = 10^{-5} \Rightarrow t_p = 1.5 \text{ h}$$

# OGLE-2005-BLG-390

*Beaulieu, Bennett et al. 2006, Nature*



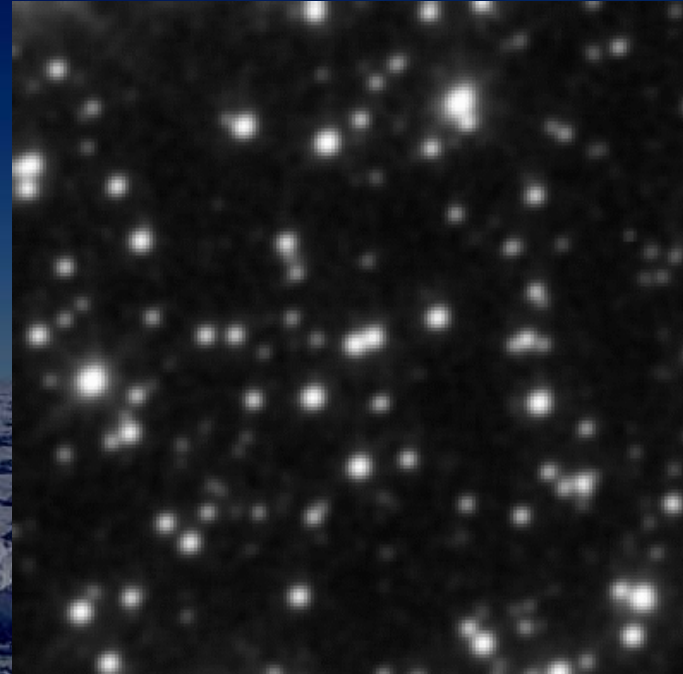
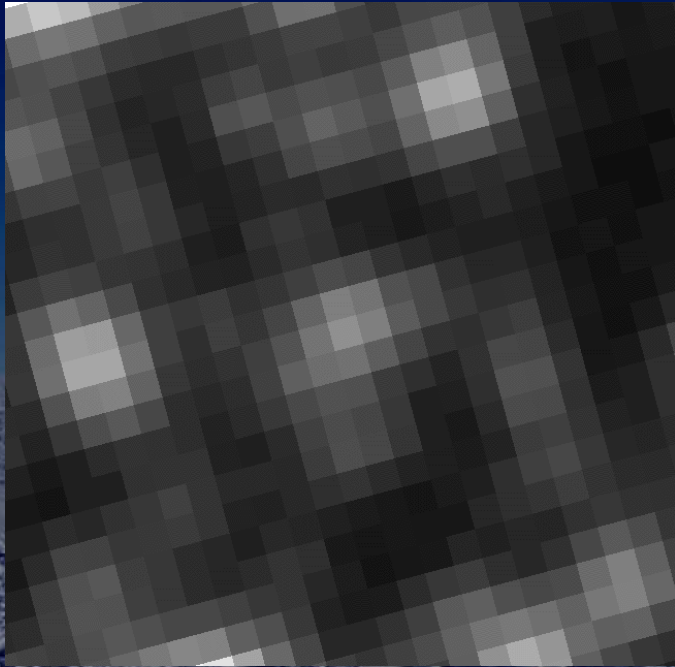
# Sensitivity to Earths Depends on Source Size



- If planetary Einstein Ring < source star disk: planetary microlensing effect is washed out (Bennett & Rhie 1996)
- For a typical bulge giant source star, the limiting mass is  $\sim 10 M_{\oplus}$
- For a bulge, solar type main sequence star, the limiting mass is  $\sim 0.1 M_{\oplus}$

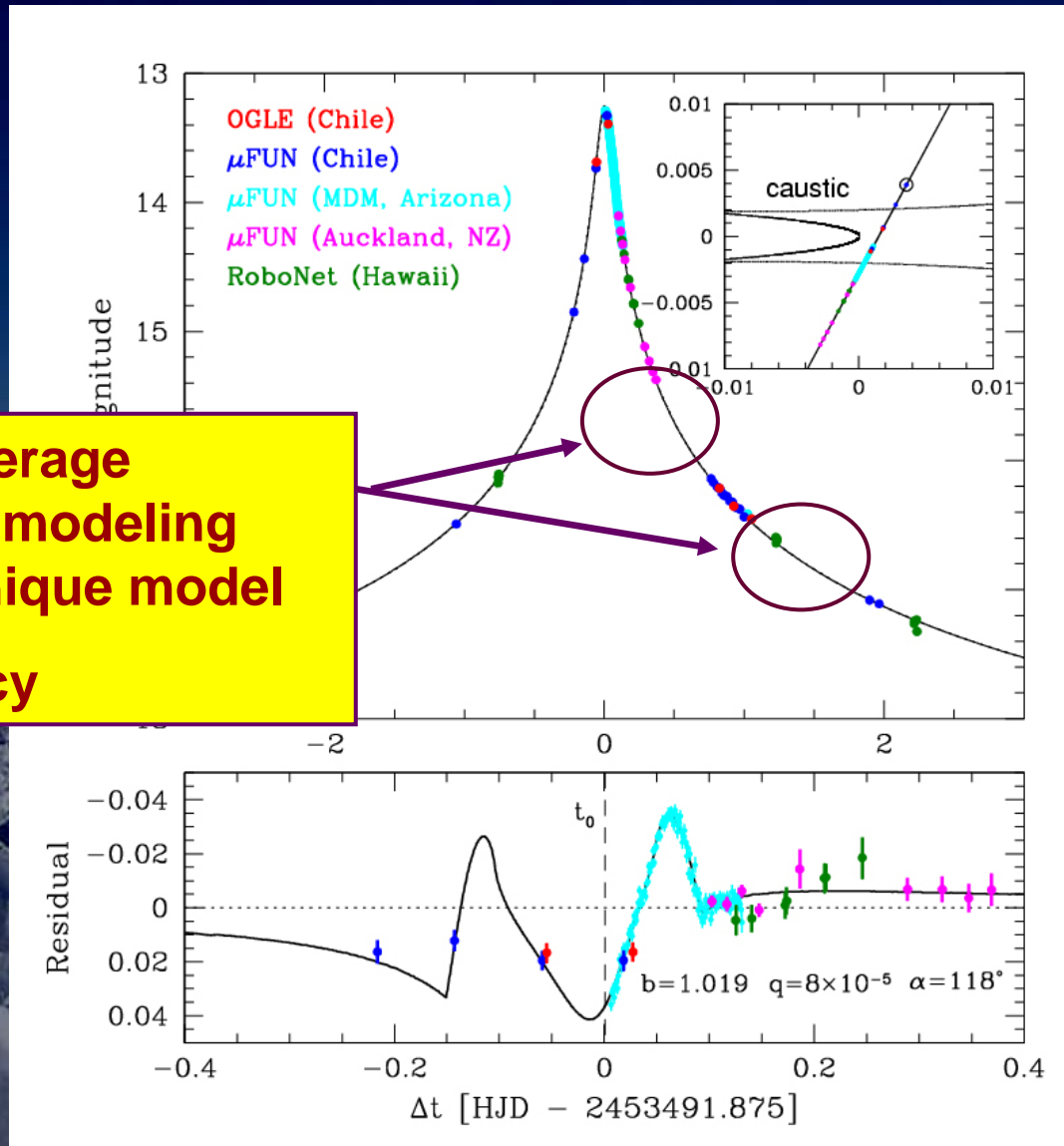
**Need to monitor small stars to get low mass planets.**

# Ground-based confusion, space-based resolution

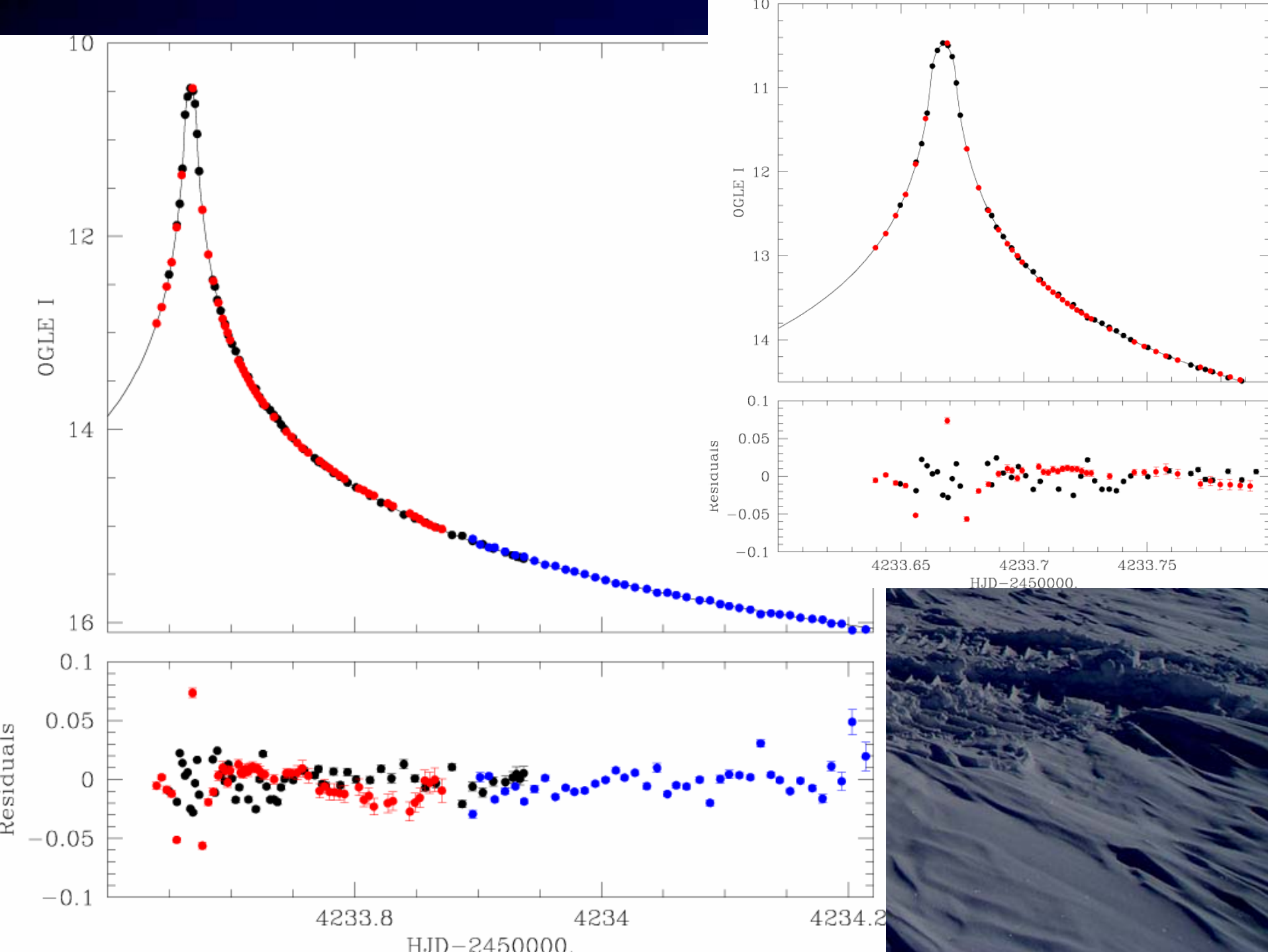


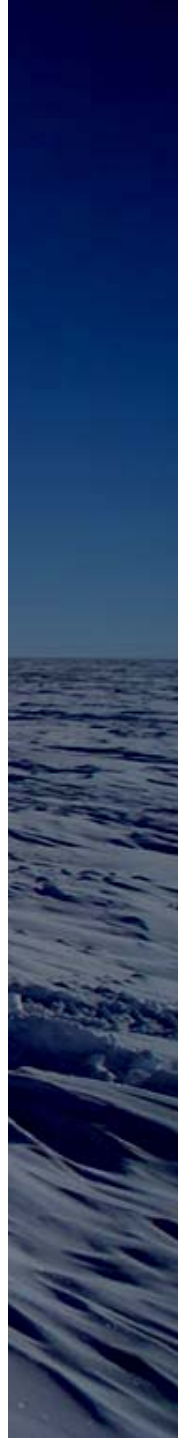
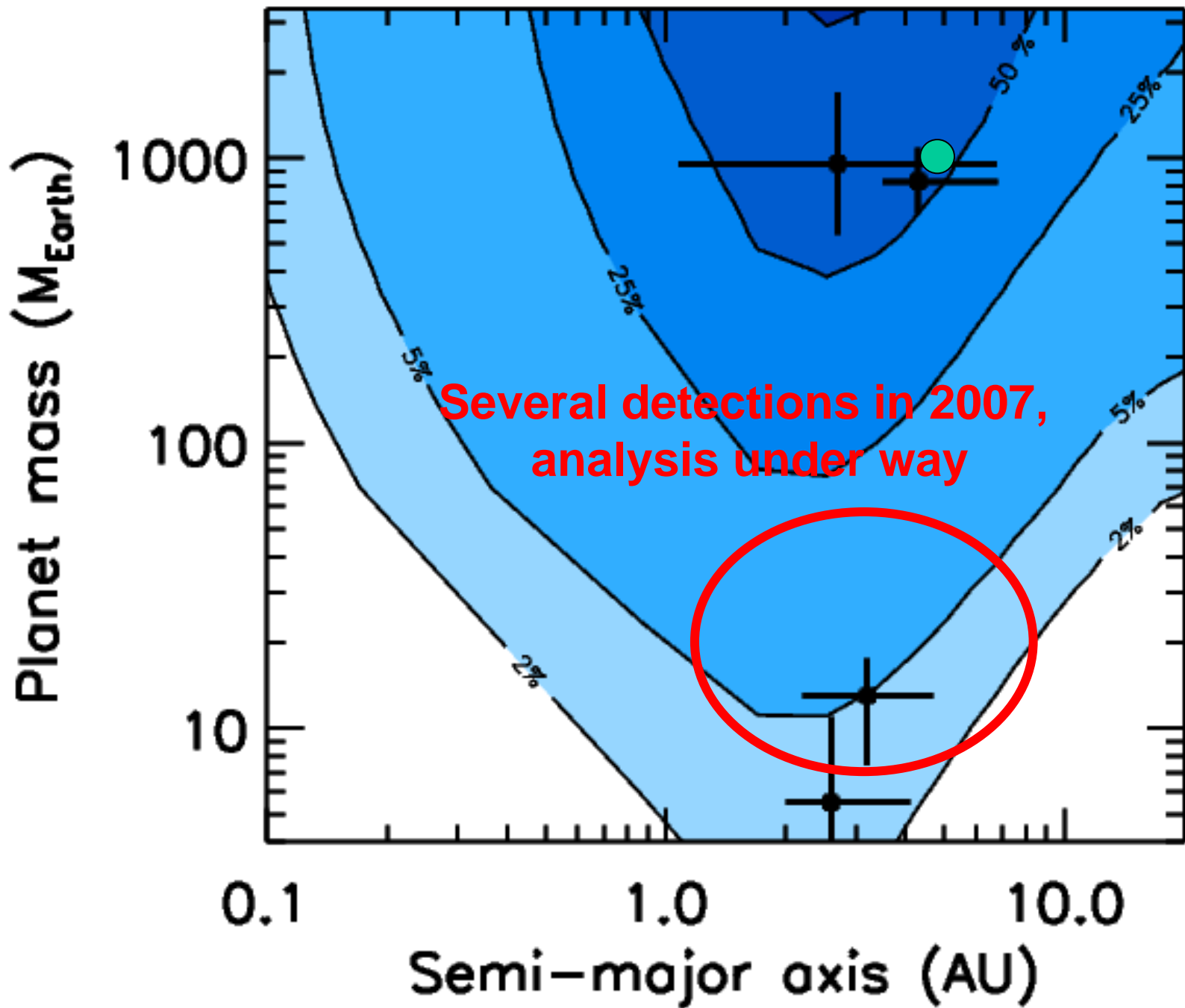
- High Resolution + wide field + 24hr duty cycle
  - Get all events (including low amplification ones)
- Or continuous monitoring of very high magnification ( $A > 300$ )
  - Need for “less” angular resolution + small field + smaller telescope

# a weak Neptune planet signal

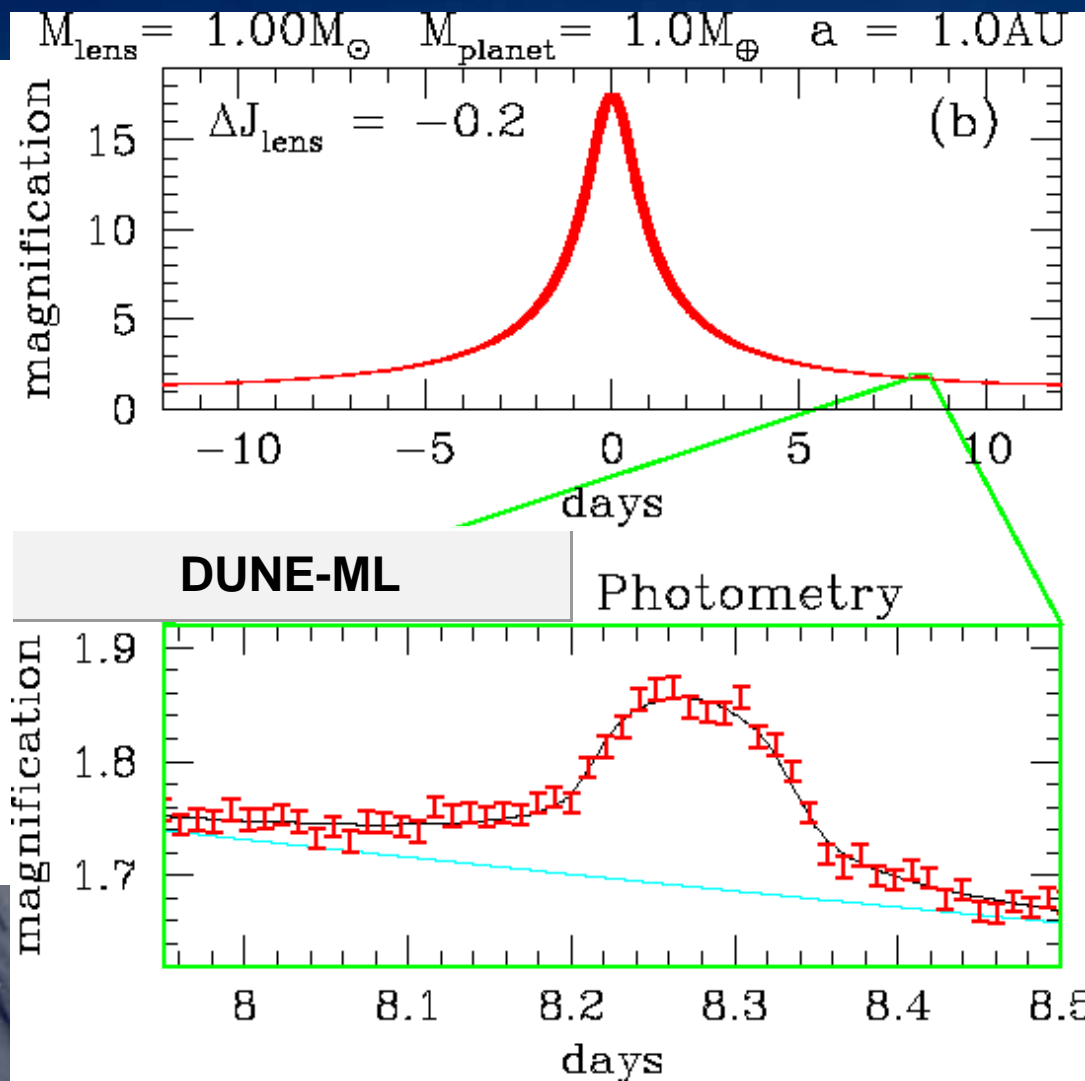
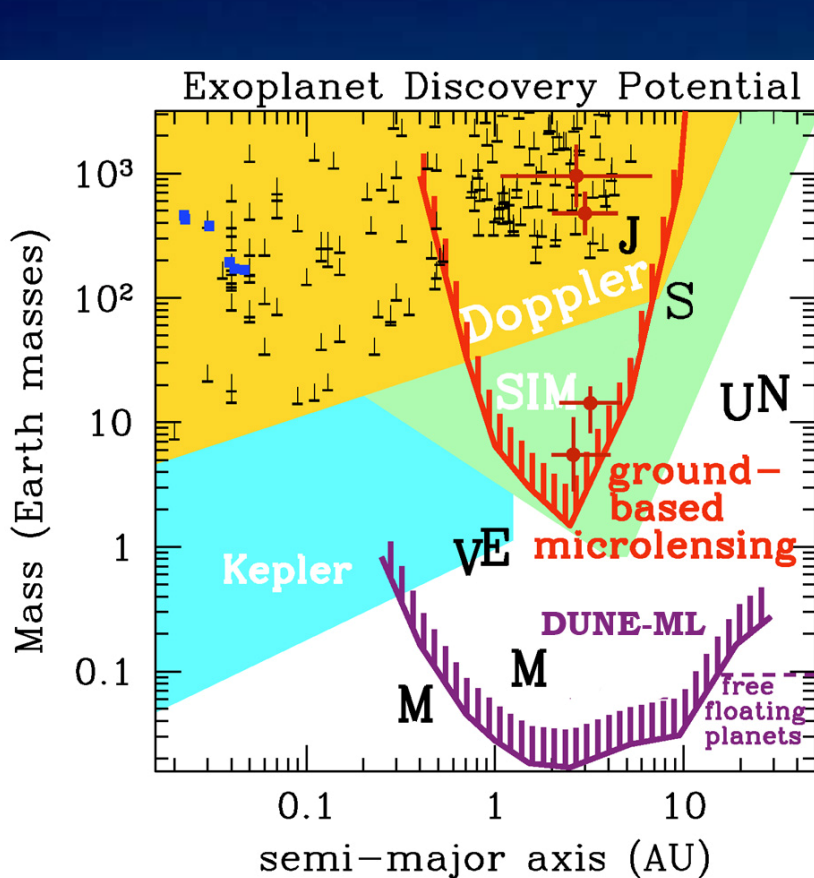


**Gaps in the coverage**  
**→ difficulties in modeling**  
**and finding a unique model**  
**Loss in efficiency**





# With 0.4 arcsec FWHM on board of DUNE



- **Microlensing :**
- **Good duty cycle from DOME – C, excellent seeing, optical, nearIR.**

**What would be competitive :**

**Quickly a ~1m to monitor few high mag events on alert in J**

**~ 1 arcsec**

**(few days continuous observing).**

**Dedicated 2m on a 30m tower/ (GLAO at 15m?) with wide field imager**

**Camera of 0.6 sq deg (0.125"/ pix), 4 fields, 1 image every 20 min.**

**It should happen BEFORE DUNE, MPF.**

# CONCLUSION From Roscoff Talk

- Do we have a good reason to go to dome C for « small projects » in 2008-2010 ?
- for « larger projects » in 2012+ ?
- Are they really up to date with the competition ?

**Radial velocity searches** : no need for a frozen HARPS (for exoplanets)

Optical/nearIR would both be good for :

**Transit searches** :

A quick pathfinder to do a bit of site testing and discover few hot Jupiters ?  
A larger scale operation, superwide field, or deep search with 2m class ?

**Characterisation of transiting planets** :

Primary and secondary eclipses with an existing IR telescope.

**Microlensing** :

Follow up of few high mag events with ~1m class telescope  
Wide field imager on a 2m telescope (Earth in habitable zone hunting)

# CONCLUSION of today

Already several projects down the road for transit detection  
(A STEP, ICE T, ...)

Need for a fast project with important visibility.

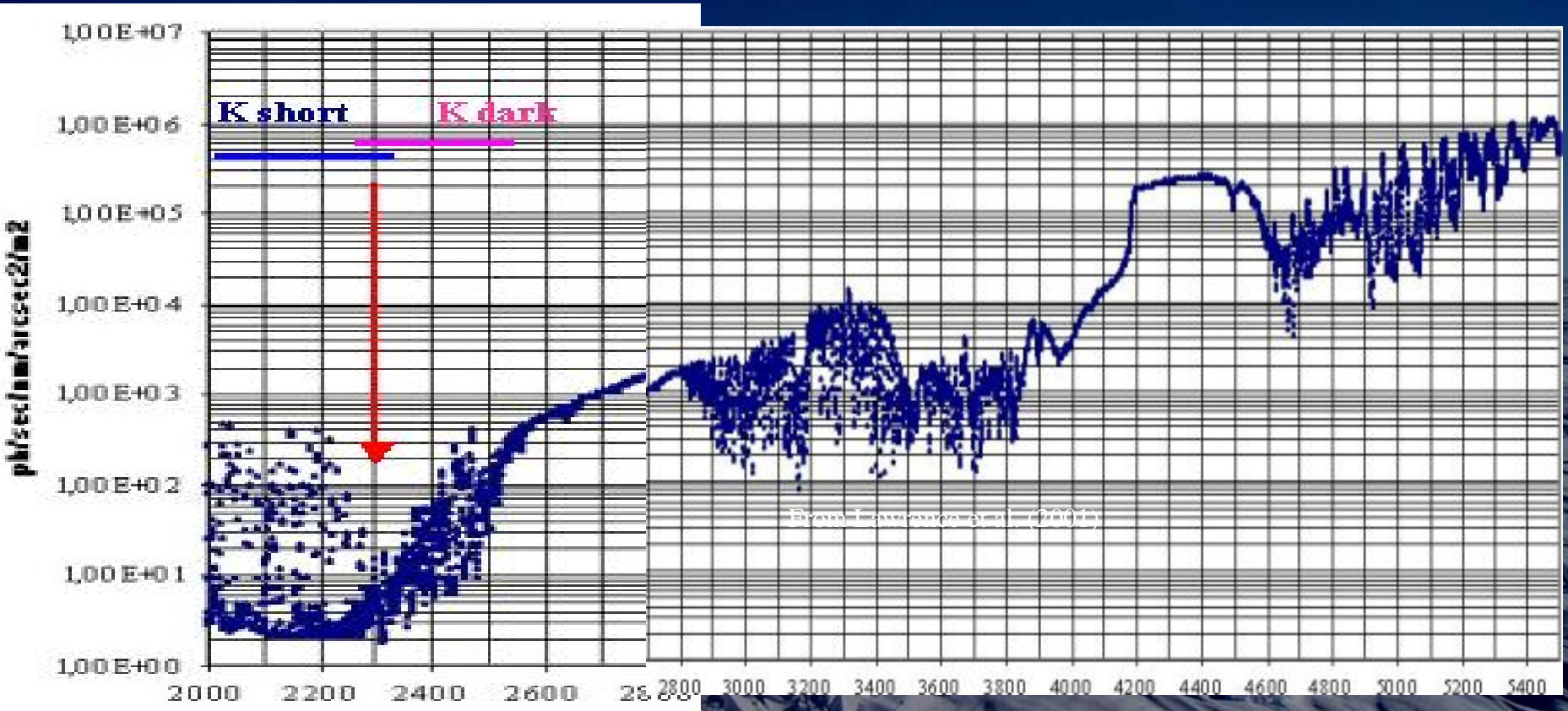
« Quickly » a 1m, on a 15m tower :

- with a 1k IR detector for microlensing monitoring of very high mag  
(Statistics of Earth mass planets at few AUs)

A telescope with IR spectro

- IR spectro for monitoring primary and secondary transits  
(Water, Methane, CO, clouds, hot Jupiter and hot Neptunes)  
excentricity

# Atmospheric emission between 2 et 5.5 $\mu\text{m}$



# Atmospheric transmission between 1.2 et 5.5 $\mu\text{m}$

