EUCLID microlensing planet hunting

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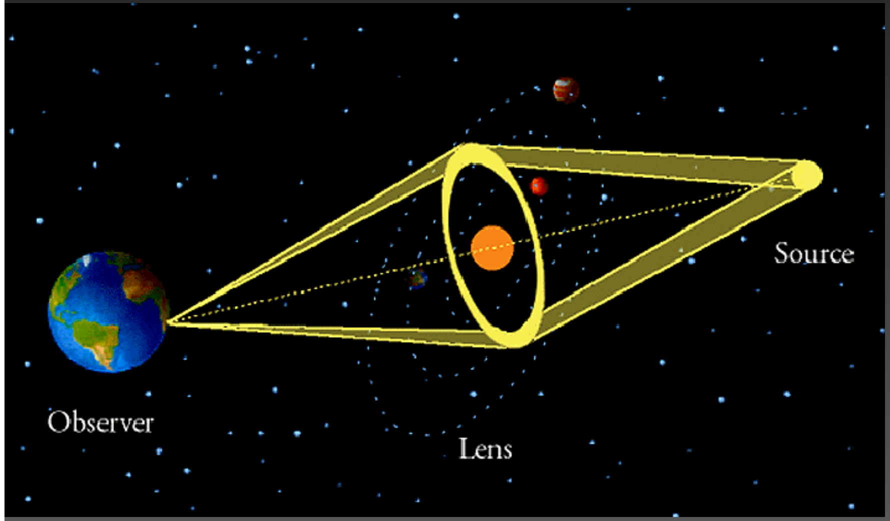
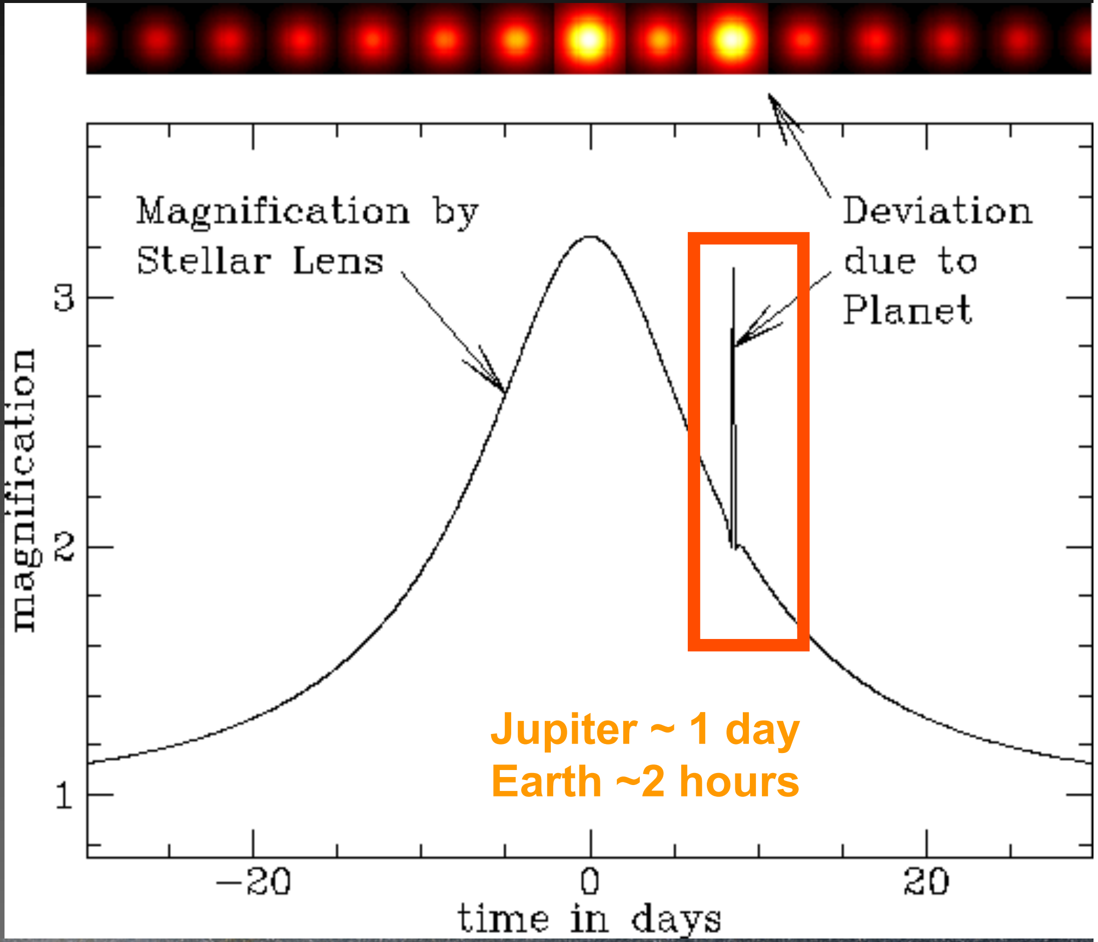
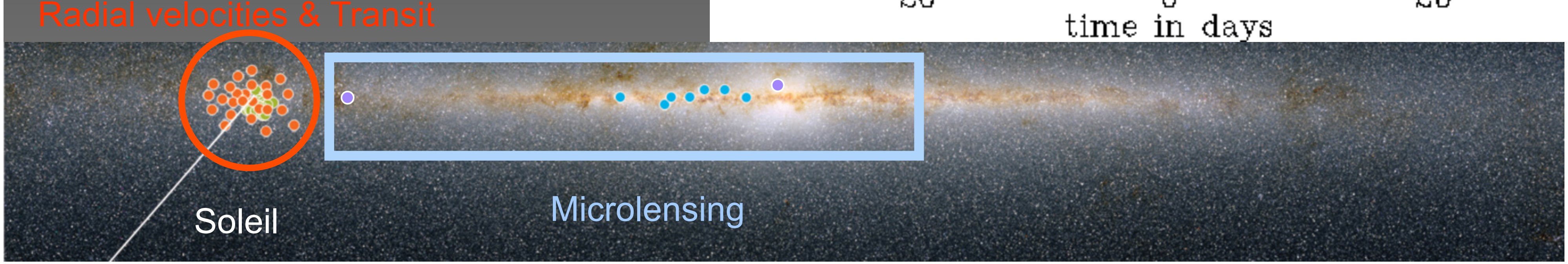
Partners in crime : P. Fouqué, P. Tisserand, E. Kerins, V. Batista, M. Penny, C. Coutures, J.B. Marquette, M. Zapatero and the EUCLID Science Working Group on exoplanets

How to detect a planet via microlensing

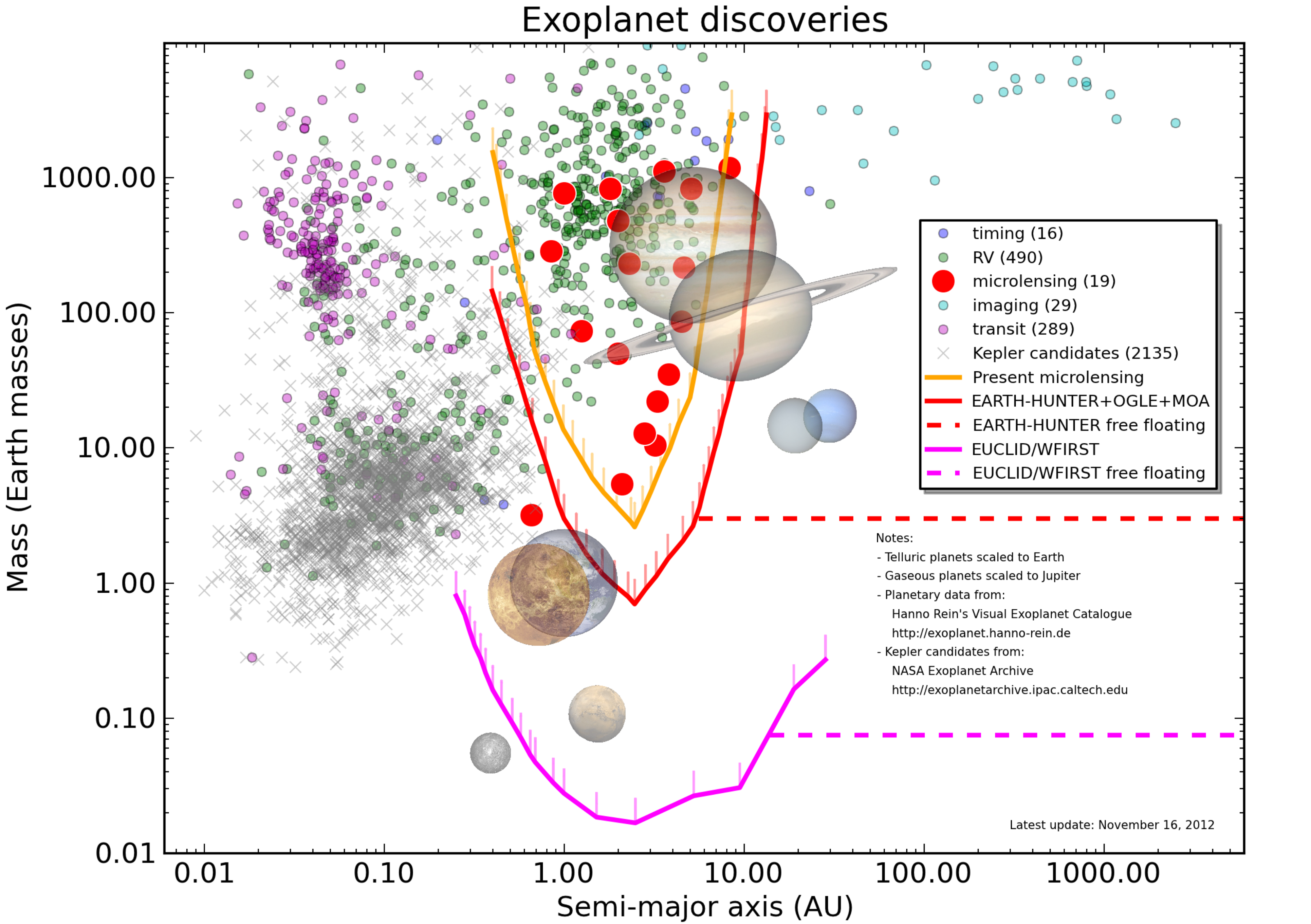






What is microlensing good for?

- <u>Extending the exoplanet discovery space:</u> capable of finding low-mass planets beyond the snow line
- <u>Understanding exoplanet architecture:</u> microlensing is able to characterise multiple-planet analogues of our solar system
- <u>Putting planet formation theories to the test:</u> microlensing sensitivity is right where core-accretion models predict the bulk of planet formation takes place


Exoplanet discoveries
Mass (Earth masses)
Semi-major axis (AU)
0.01
0.10
1.00
10.00
100.00
1000.00
timing (16)
RV (490)
microlensing (19)
imaging (29)
transit (289)
Kepler candidates (2135)
Present microlensing
EARTH-HUNTER+OGLE+MOA
EARTH-HUNTER free floating
EUCLID/WFIRST
EUCLID/WFIRST free floating
Notes:
- Telluric planets scaled to Earth
- Gaseous planets scaled to Jupiter
- Planetary data from:
Hanno Rein's Visual Exoplanet Catalogue
http://exoplanet.hanno-rein.de
- Kepler candidates from:
NASA Exoplanet Archive
http://exoplanetarchive.ipac.caltech.edu
Latest update: November 16, 2012

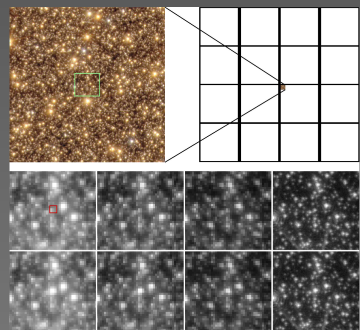
EUCLID microlensing

Telescope parameters	
Diameter (m)	1.2
Central blockage (m)	0.4
Slew + settle time (s)	85(285)

Detector parameters				
Instrument	VIS		NISP	
Filter	*RIZ*	*Y*	*J*	*H*
Size (pixels)	24k × 24k		8k × 8k	
Pixel scale (arcsec)	0.1		0.3	
PSF FWHM (arcsec)	0.18	0.3*	0.36*	0.45*
Bias level (e^-)	380†		380†	
Full well depth (e^-)	2^{16}		2^{16}	
Zero-point (ABmag)	25.58⋆	24.25⋆⋆	24.29⋆⋆	24.92⋆⋆
Readout noise (e^-)	4.5	7.5*	7.5*	9.1*
Thermal background (e^- s^{-1})	0	0.26	0.02	0.02
Dark current (e^- s^{-1})	0.00056◇		0.1*	
Systematic error	0.001†		0.001†	
Diffuse background (ABmag $arcsec^{-2}$)	21.5‡	21.3‡	21.3‡	21.4‡
Exposure time (s)	540(270)	90	90	54
Images per stack	1	3(1)	3(1)	5(2)
Readout time (s)	< 85		5†	

Besançon model

Microlensing simulator
3 fields, 270 sec per pointing,
5x2 months observing



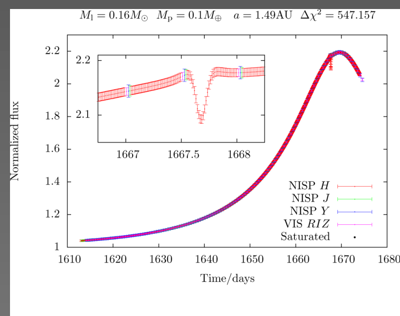
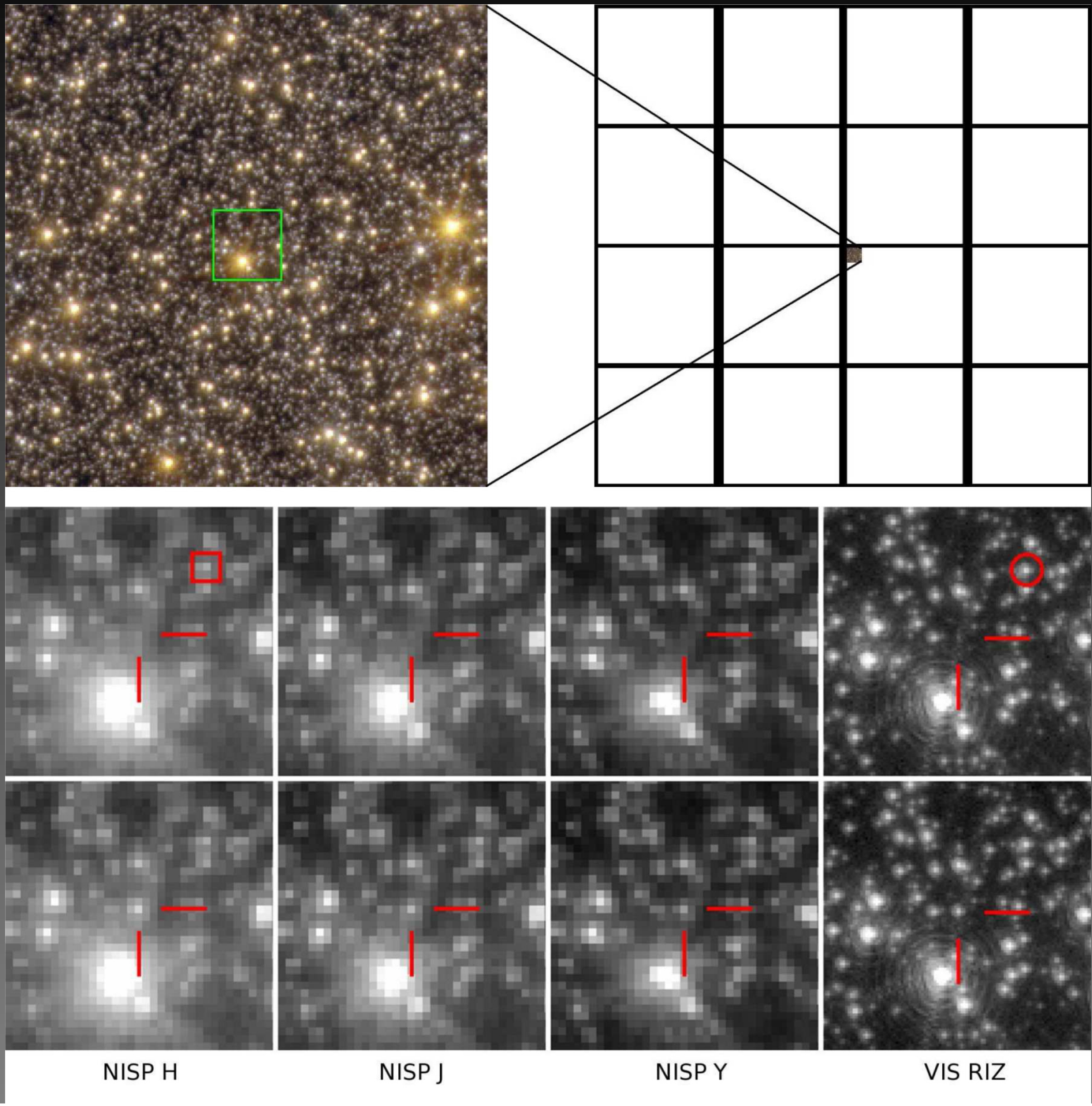


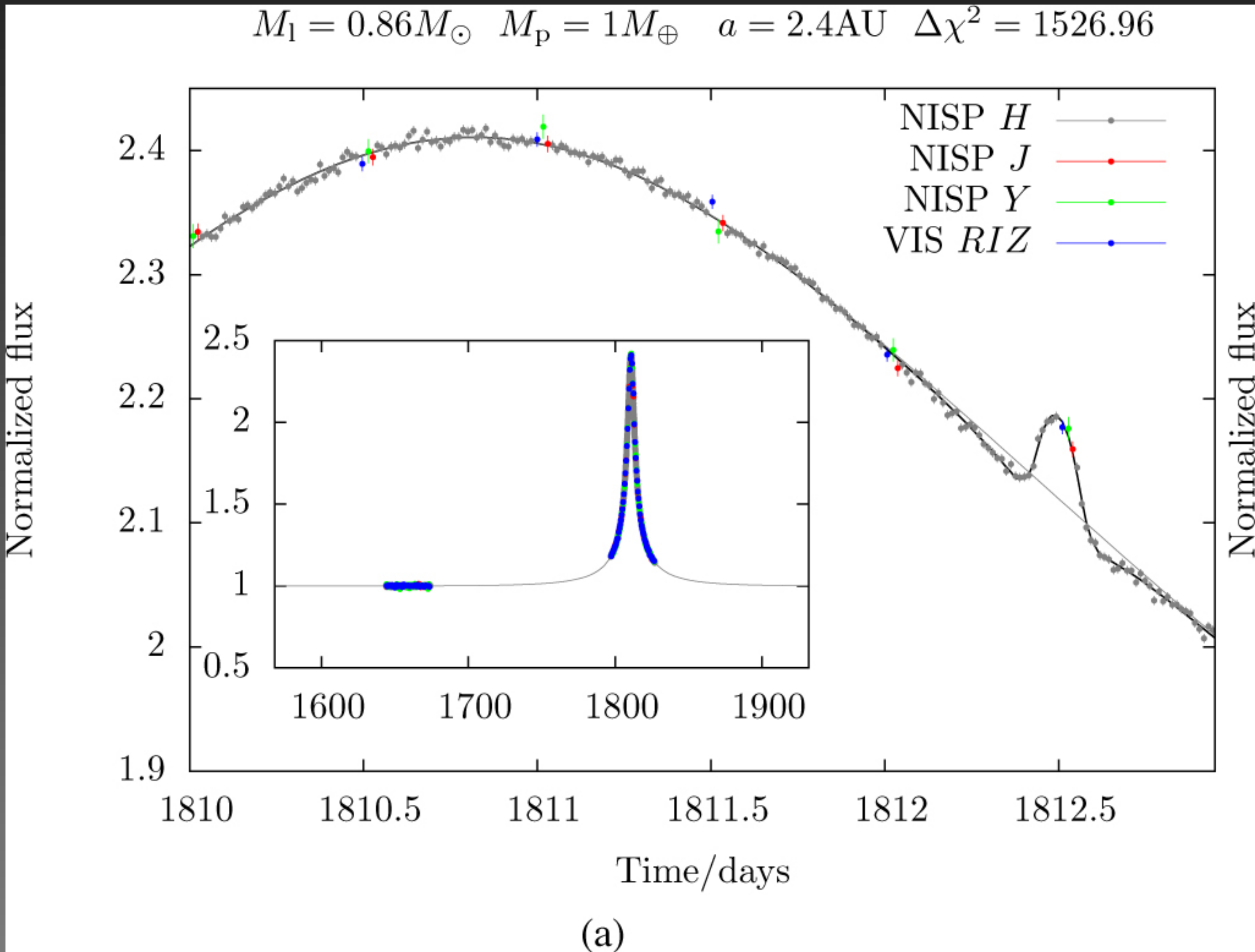
Figure 3. Example lightcurves

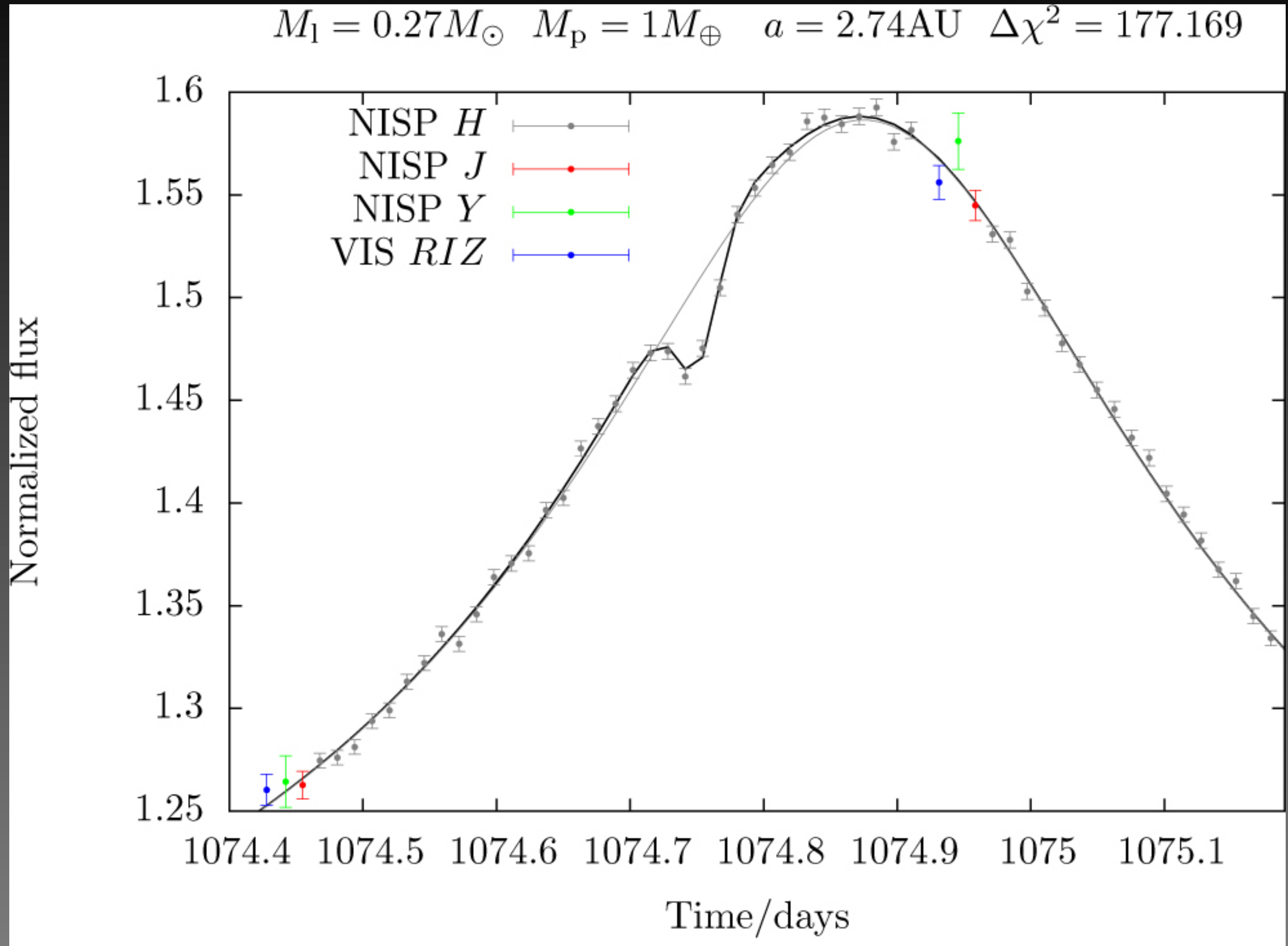
Penny, Kerins, Rattenbury, Beaulieu, et al., 2012, MNRAS submitted
PhD Matthew Penny

Simulated images of galactic Bulge



EUCLID will detect Earth mass planets

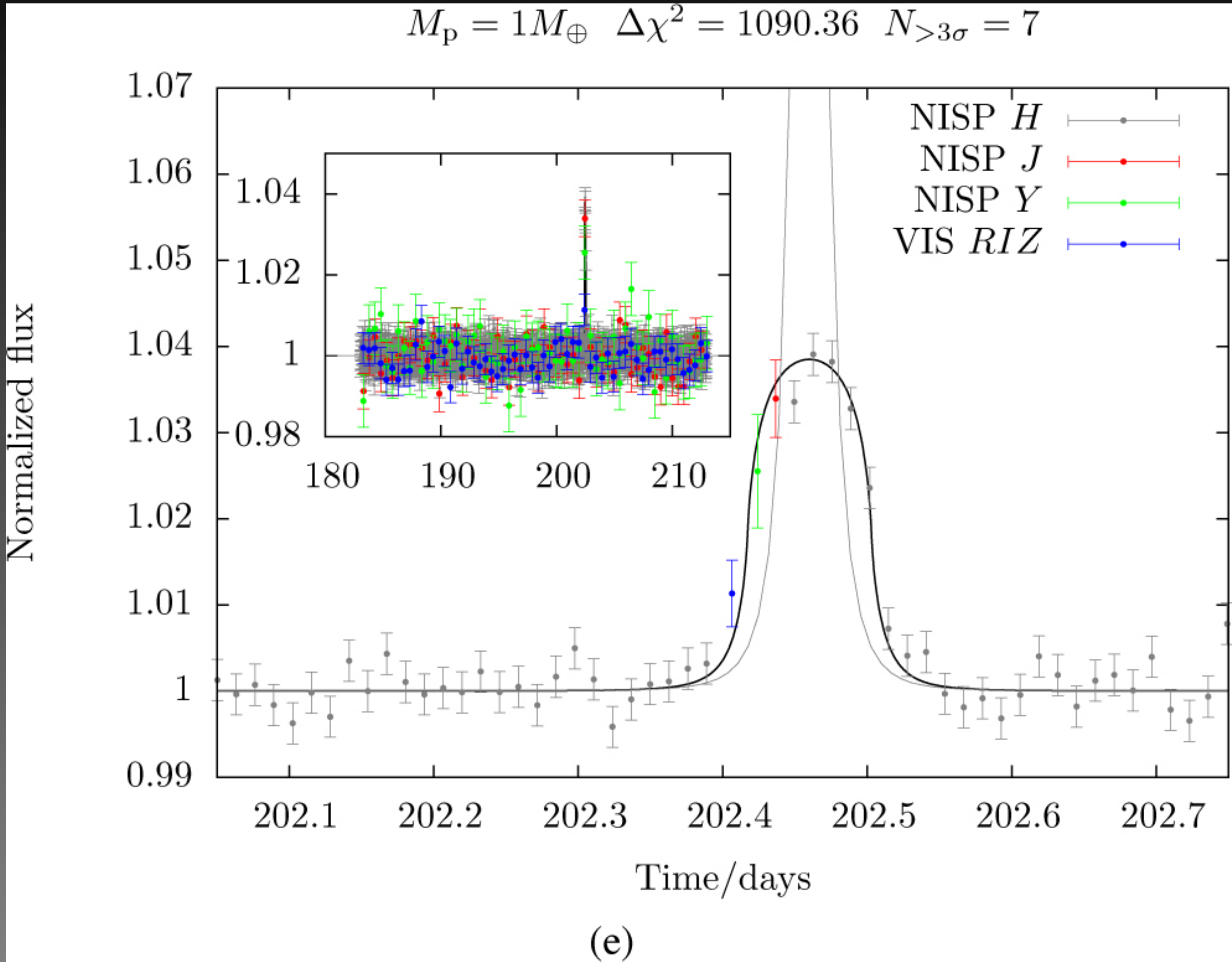




$M_l = 0.27M_\odot$ $M_p = 1M_\oplus$ $a = 2.74$AU $\Delta\chi^2 = 177.169$
NISP H
NISP J
NISP Y
VIS RIZ
Normalized flux
Time/days
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1074.4
1074.5
1074.6
1074.7
1074.8
1074.9
1075
1075.1

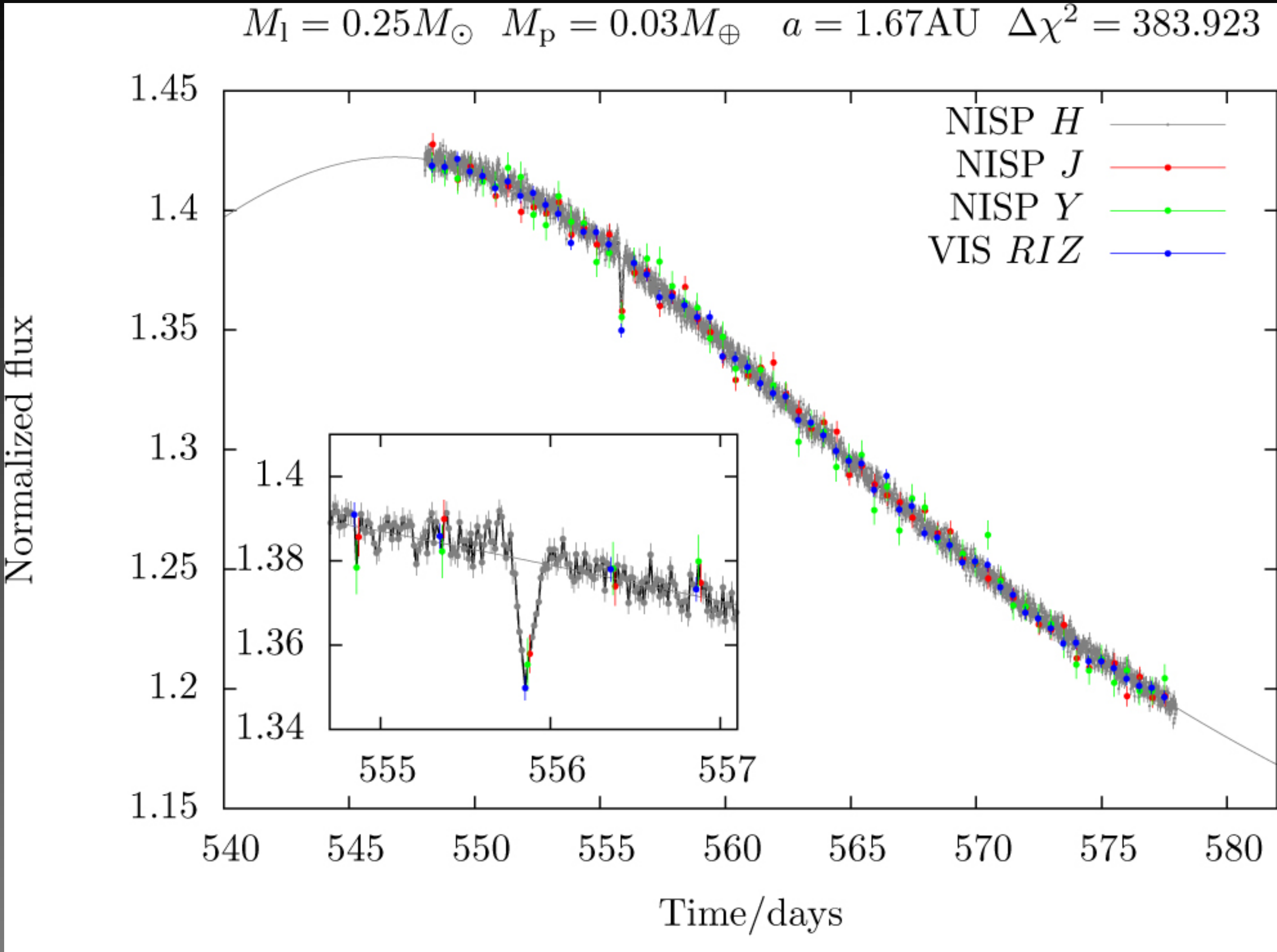
(c)

EUCLID will detect free floating Earth



(e)

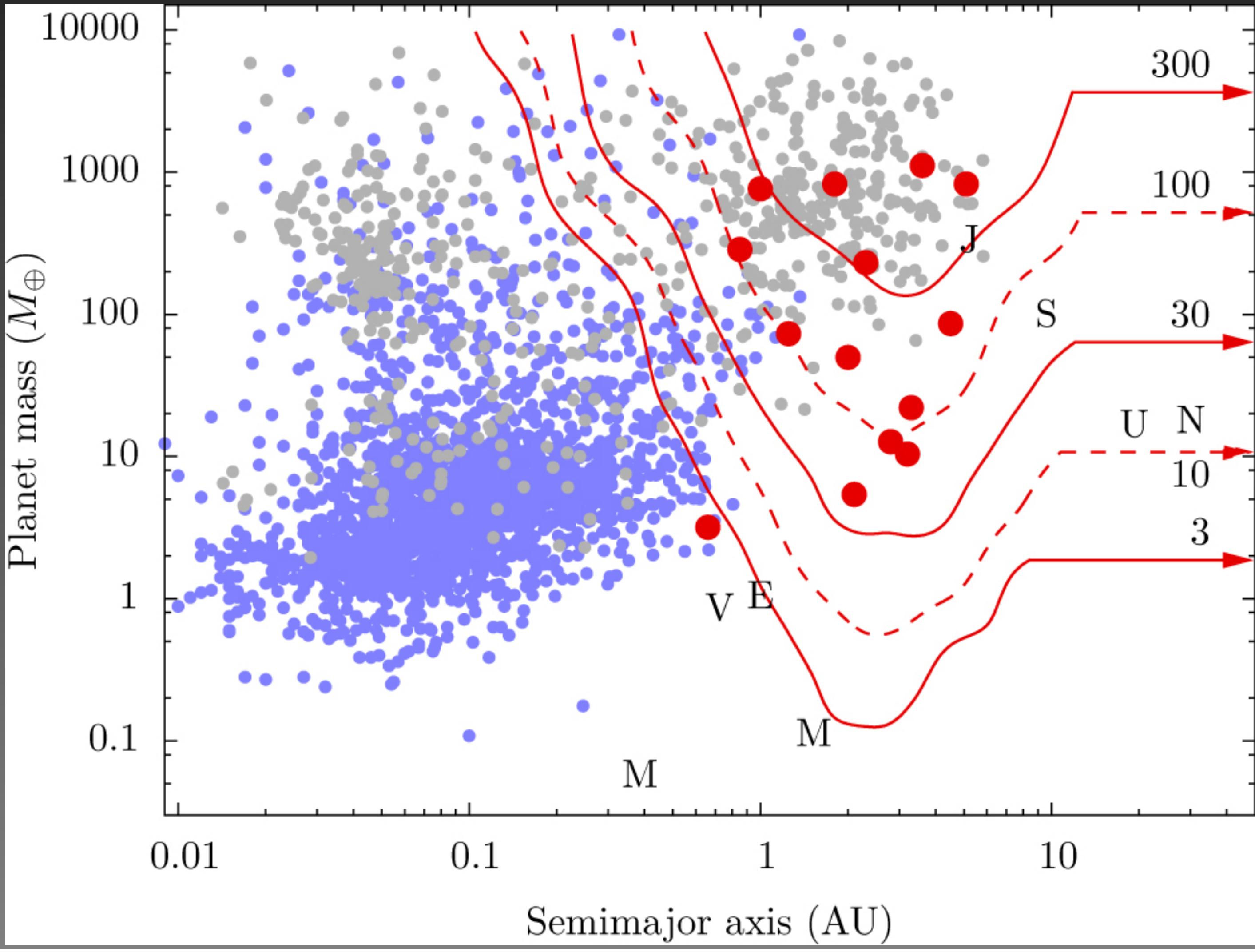
EUCLID will detect very low mass planets



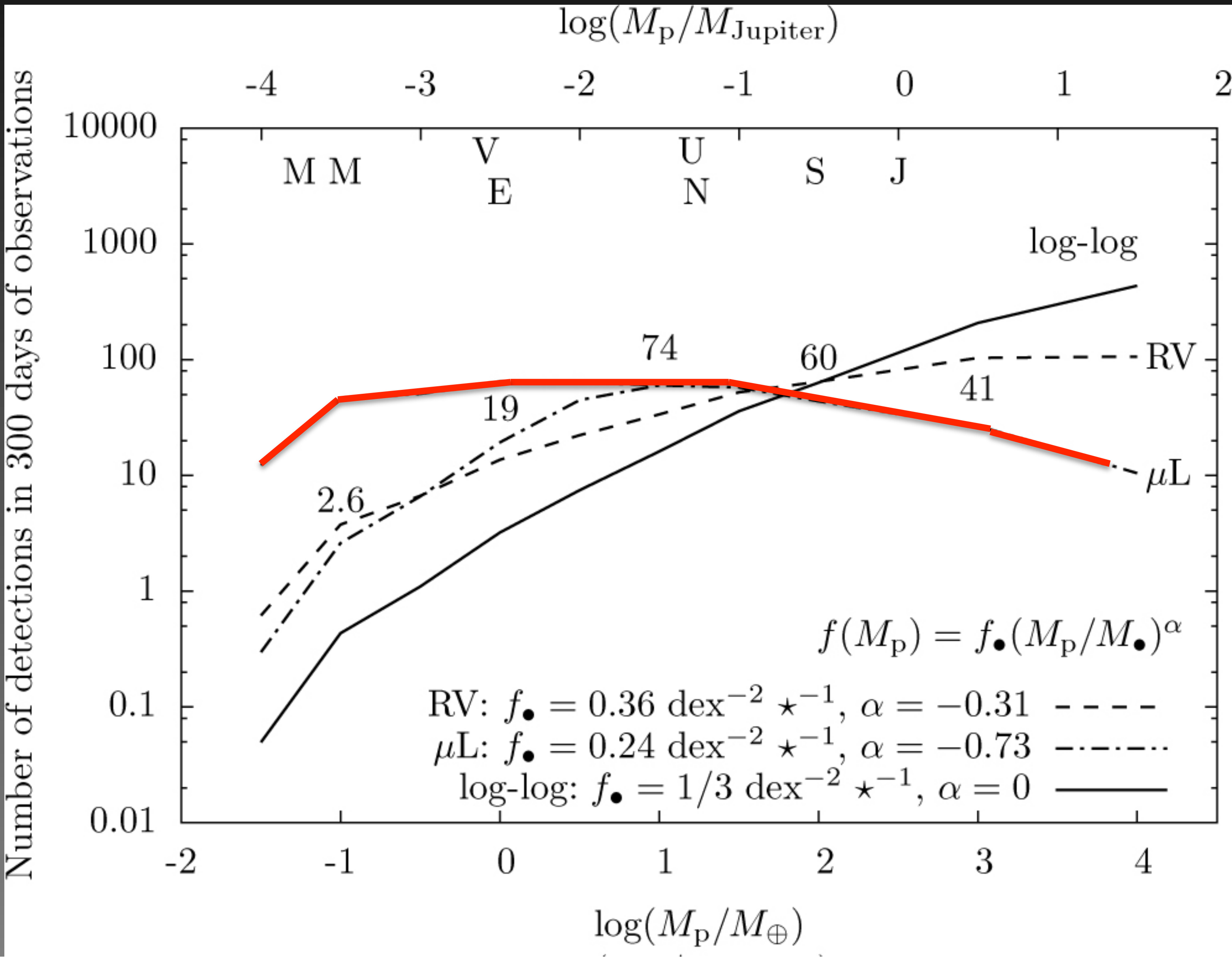
(d)

EUCLID planet catch with 300 days

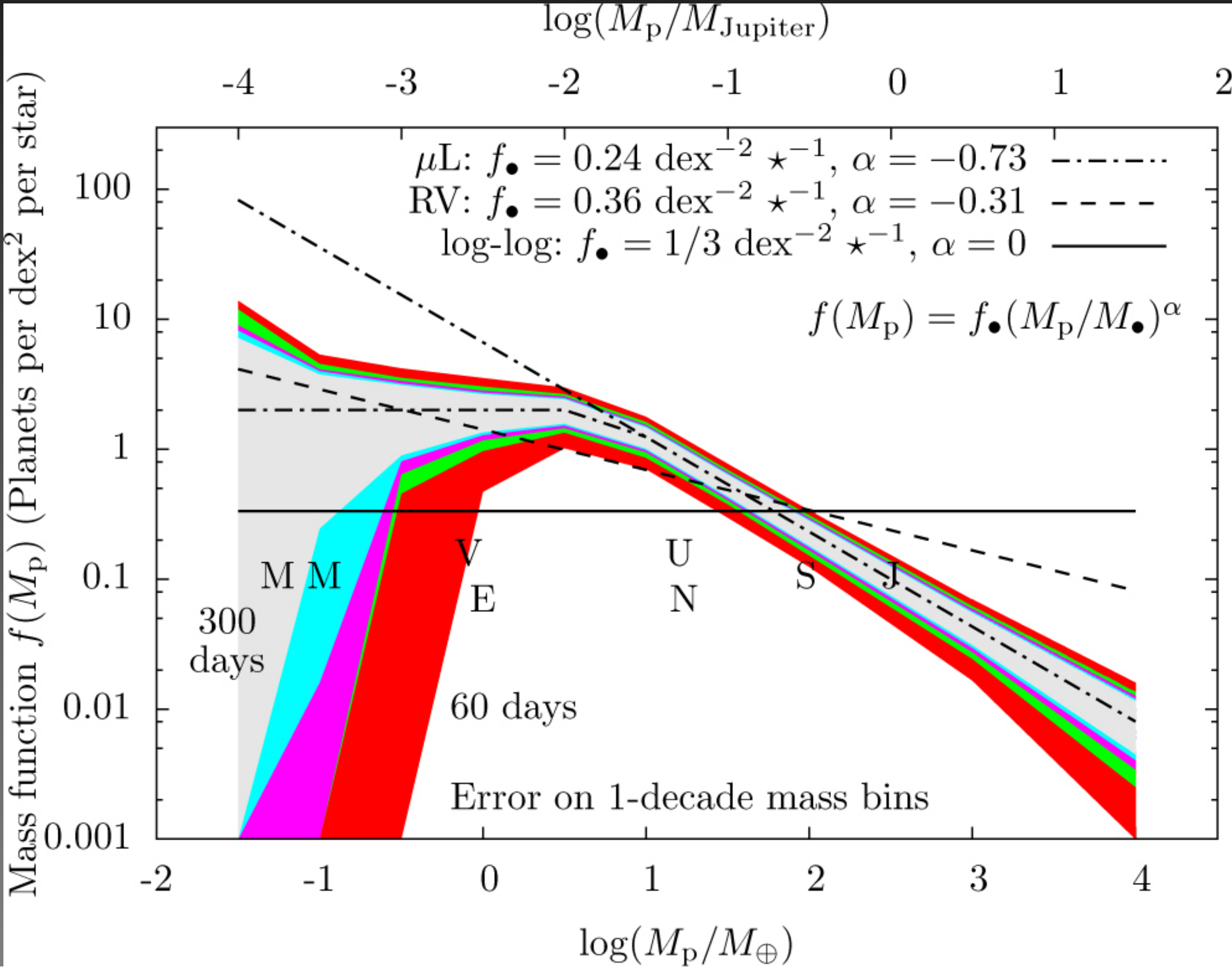
1 planet of mass Mp within 0.03-30 AU (pessimistic)



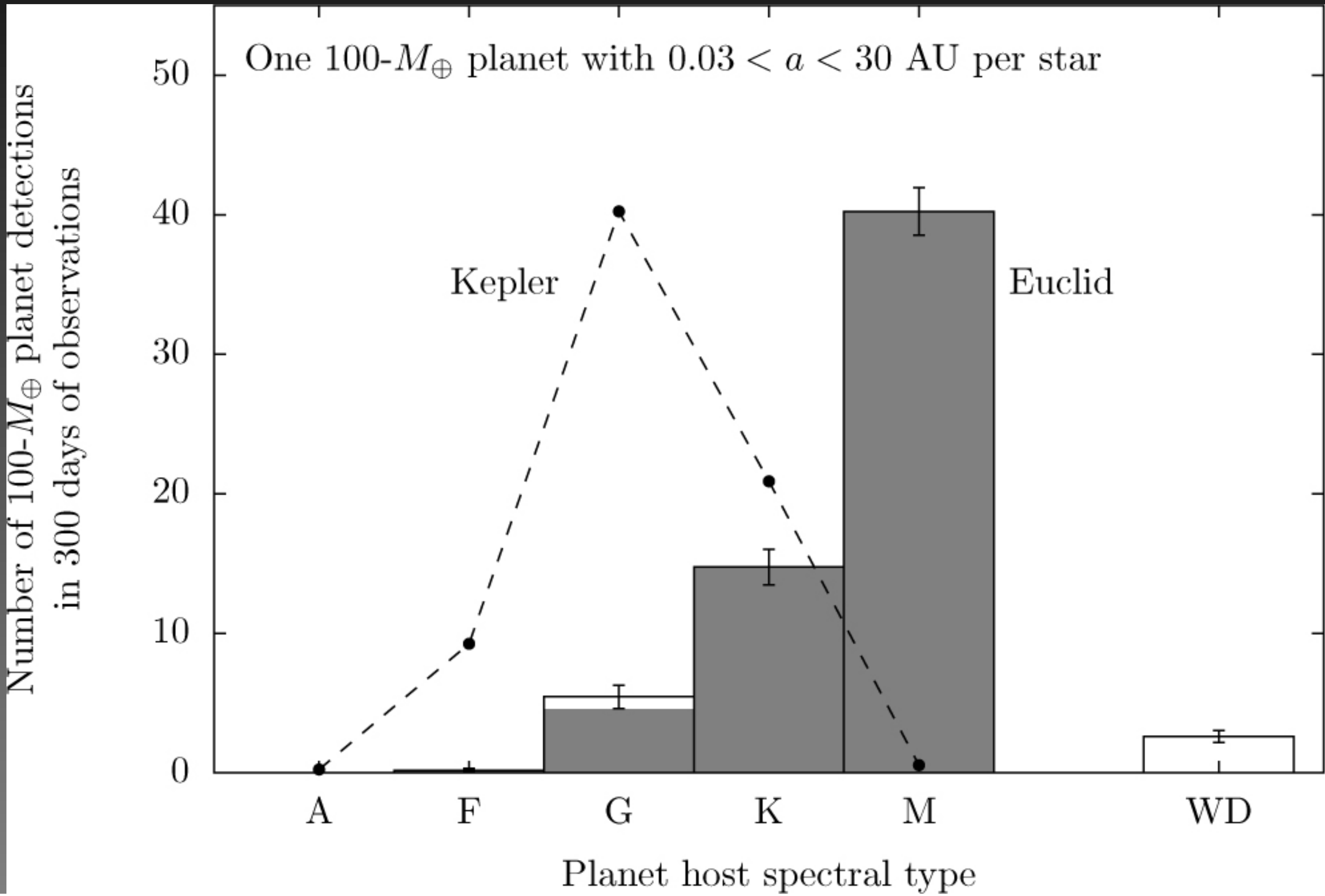
EUCLID planet catch with 300 days



Constraint on mass function 60, 120, 240, 300 days survey



Different population of host stars complement & overlap with Kepler



Microlensing program on board the EUCLID Dark Universe Probe

- Currently in additionnal science
- EUCLID understood the excellent synergy cosmic shear/microlensing requirements
- EUCLID/ML complements parameter space probed by RV and KEPLER
- Full census on planets down to Mars mass, getting $\eta_{\oplus}$(Abundance of habitable Earth)
- Getting free floating planets down to the mass of Earth
- From frozen to snow line to habitable planets

Penny,et al. 2012, MNRAS submitted, on astroph

And with 6 months of EUCLID microlensing before WFIRST launch, we can harvest most of the Science they are targeting...

Microlensing program on board the EUCLID Dark Universe Probe

Penny et al., 2012, MNRAS, « ExELS: an exoplanet legacy science proposal for the ESA Euclid mission I. Cold exoplanets, arXiv:1206.5296

Beaulieu et al., 2010, "EUCLID : Dark Universe Probe and Microlensing planet Hunter", arXiv:1001.3349