EUCLID,
the planet hunter

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Companion talks by Jason Rhodes, Eamonn Kerins & Matthew Penny
WFIRST microlensing : Dave Bennett, Scott Gaudi

Heard several time this week...

There is no microlensing program on board EUCLID

Therefore we should rebrand EUCLID into...

WONLY

Or even better...

FOR W ONLY


That's all Folks!

Heard several time this week...

~~There is no microlensing program on board EUCLID~~

There was a microlensing program on board DUNE (when submitted in 2007)
Dark Energy and microlensing together already in 2007

There is a microlensing program on board EUCLID as part of Legacy Science

ESA Core/Legacy Science

Core science is to understand the origin of the Universe accelerating expansion, probe nature and properties of dark energy, dark matter, gravity

Wide field survey of 15 000 sq deg,

shape and photo z of 2 10^9 galaxies, redshifts of 5 10^7 galaxies.

All the rest is Legacy science meaning :

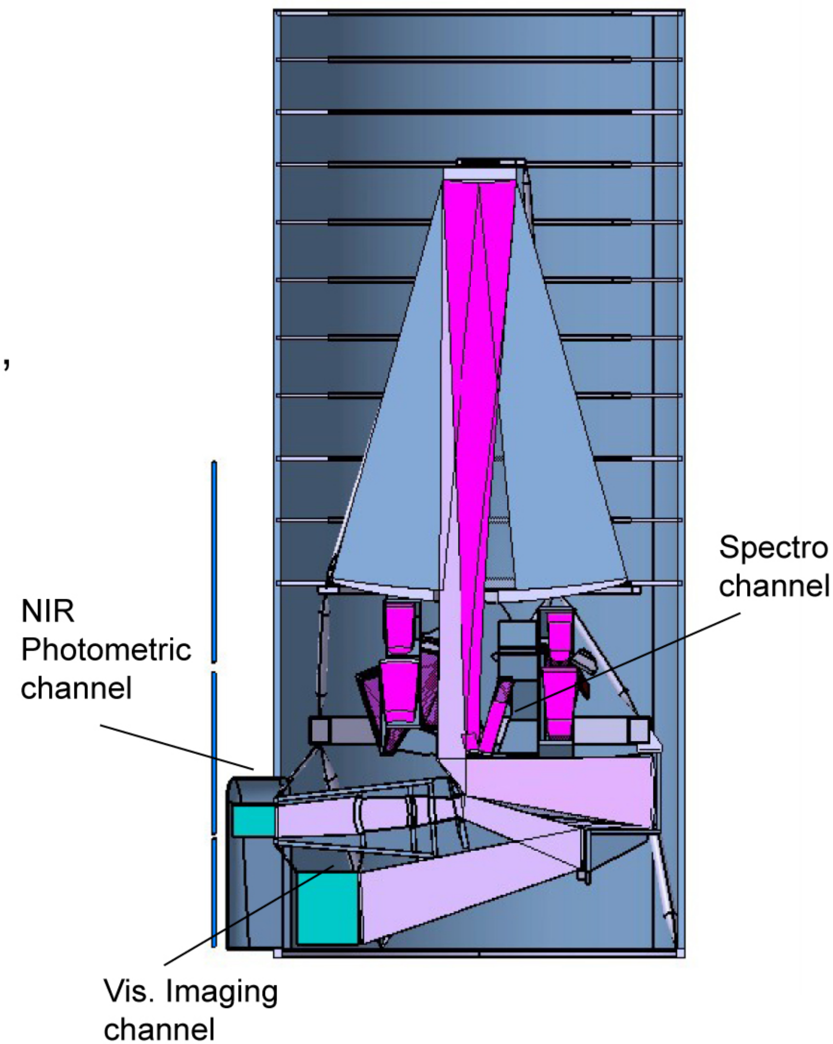
- No constraint on the design of the mission
- Should not be detrimental to core science objective

Microlensing is part of the Legacy Science

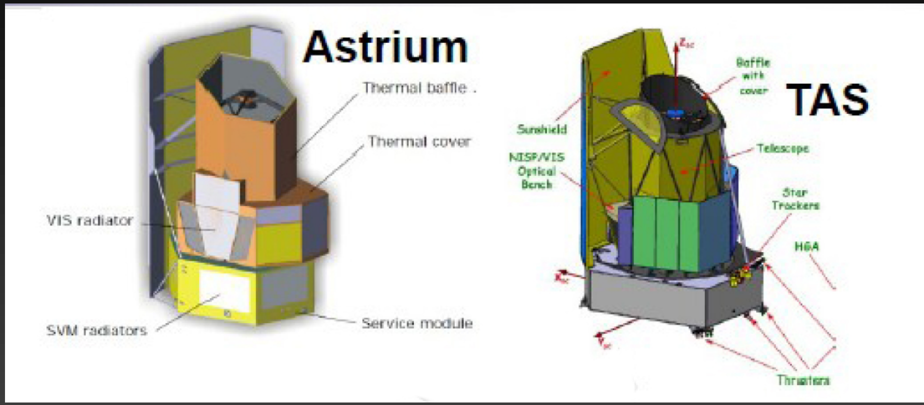
EUCLID

EUCLID spacecraft

- Launch Soyuz, end 2019 L2 Orbit
- 6 years mission
- Telescope: 1.2 m
- Instruments:
- **VIS**: Visible imaging channel:
  - 0.54 deg^2, 0.10'' pixels, 0.16'' PSF FWHM,
  - 1 broad band R+I+Z (0.55-0.92mu),
  - 36 CCD detectors, galaxy shapes
- **NISP**: NIR photometry channel:
  - 0.54 deg^2, 0.3'' pixels,
  - 3 bands Y,J,H (1.0-1.7mu),
  - 16 HgCdTe detectors, photo-z's
- **NISP**: NIR Spectroscopic channel:
  - 0.54 deg^2,
  - R(mean)=250,
  - 0.9-1.7mu, slitless, spectro redshifts



What’s happenning now ?



Still two designs in competition :

Selection by ESA in autumn 2012

We do not have full details about the two designs.

Various survey strategy under study in the coming months.

First survey : only core science (estimate gaz consumption, efficiency).

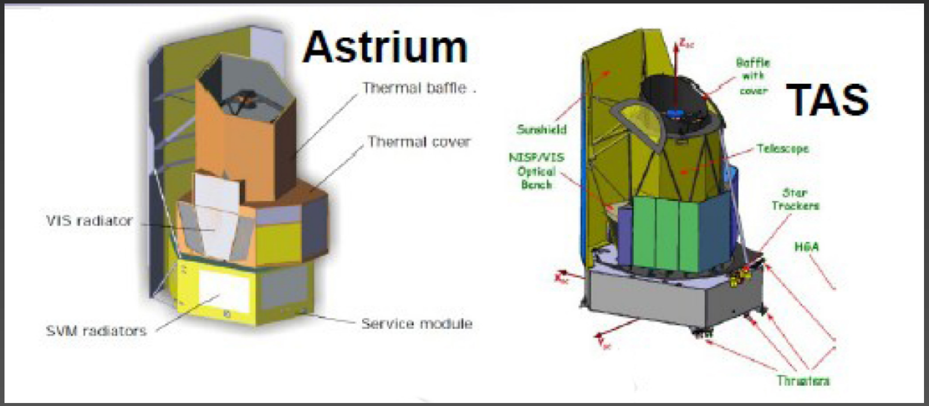
Objective : get EUCLID adopted by ESA in June 2012.

Meanwhile/then (in the coming months)

Surveys : incorporating Legacy Science to the core Science.

Time is critical

NISP Photometry exposure time: Y: 100 s, J: 95 s, H 60 s.
NISP Photometry integration time: Y: 121 s, J: 116 s, H 81 s.
VIS exposure time = 565 s



Slew time gaz : 350 sec reaction wheel : 150 sec

Slew time = slew + settling (for cosmic shear requirements)

For H, settling time will be shorter than for VIS but... unknown (to date)

WFIRST small slew goal : 30 sec (less than 60 sec as requirement)...

Sun Avoidance Angle

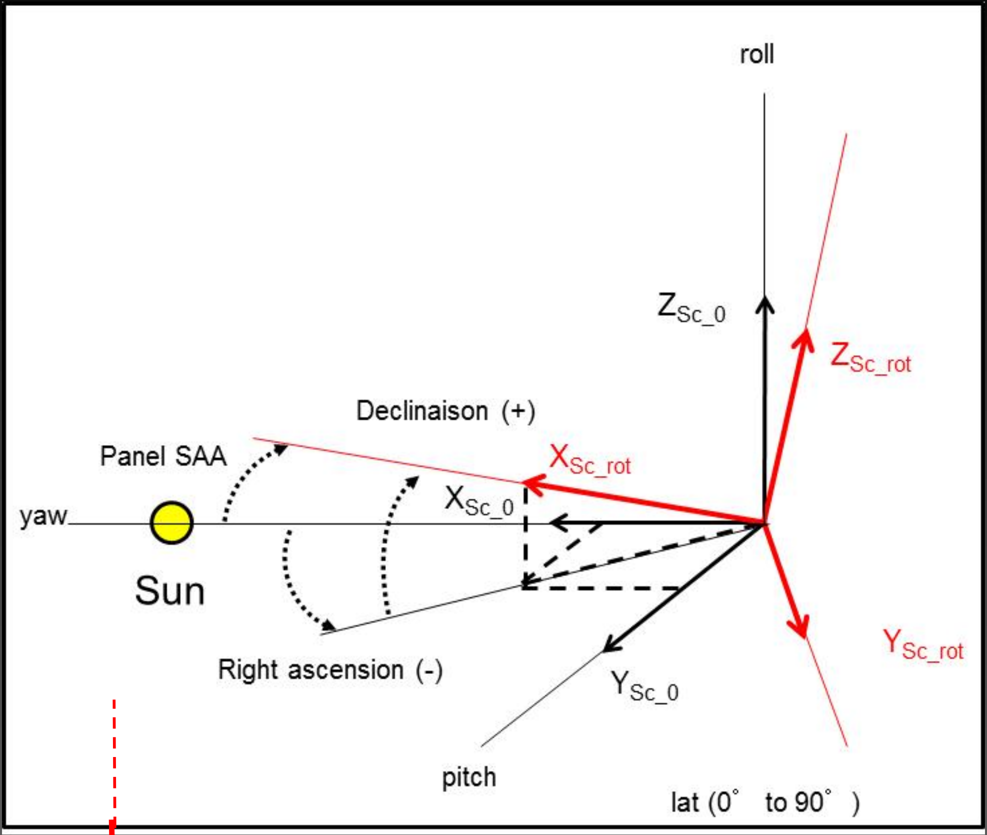
Pointing constraints

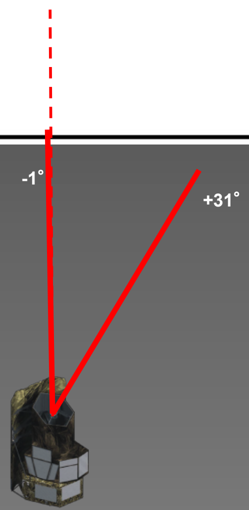
The S/C can be operated for a certain range of SAA orientations that limit depointing of the S/C:

MRD R-440-8: The EUCLID spacecraft shall be able to implement the Deep and the Wide Extragalactic Survey with a variable solar aspect angle included between 89 degrees and 121 degrees.

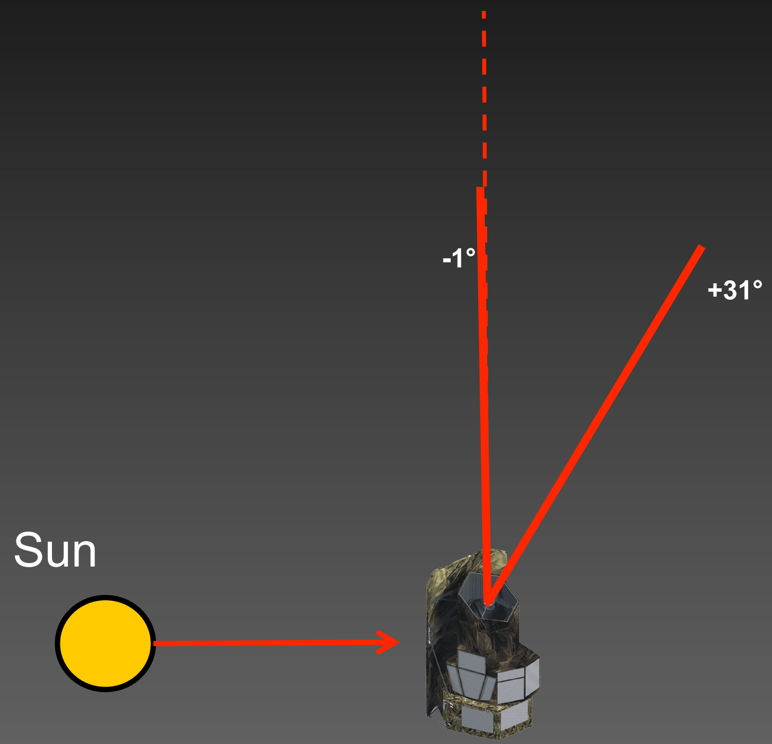
PSF stability requirements can be ensured for a given range of SAA variation around a reference pointing direction:

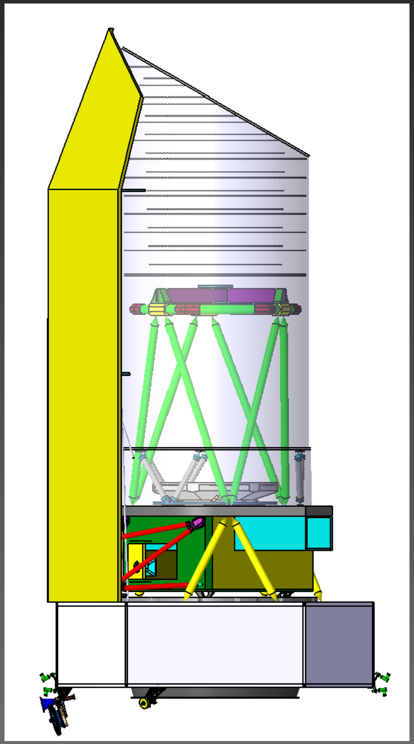
MOCD R-SYS-OP-MS-030: The EUCLID spacecraft shall be able to implement the Deep and the Wide Extragalactic Survey with a variable solar aspect angle included between 90 degrees and 95 degrees.





Work Flow for Survey Optimisation





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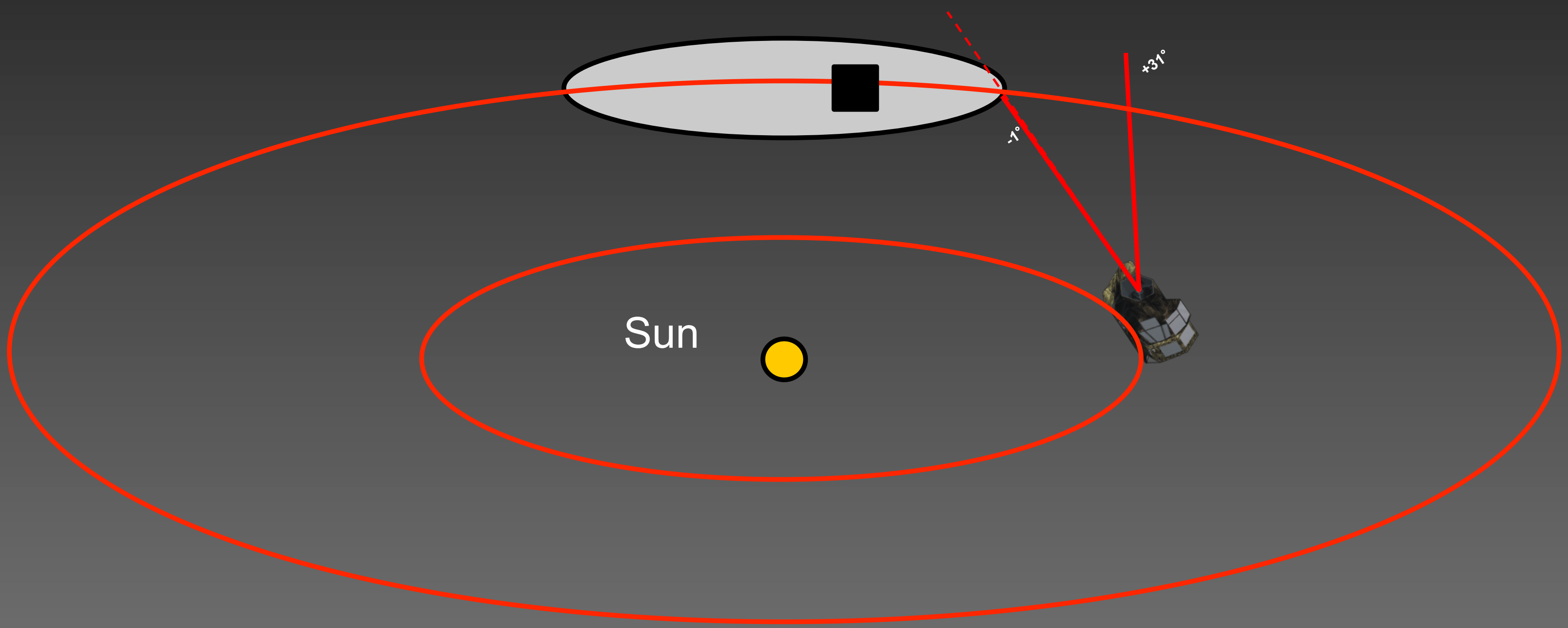

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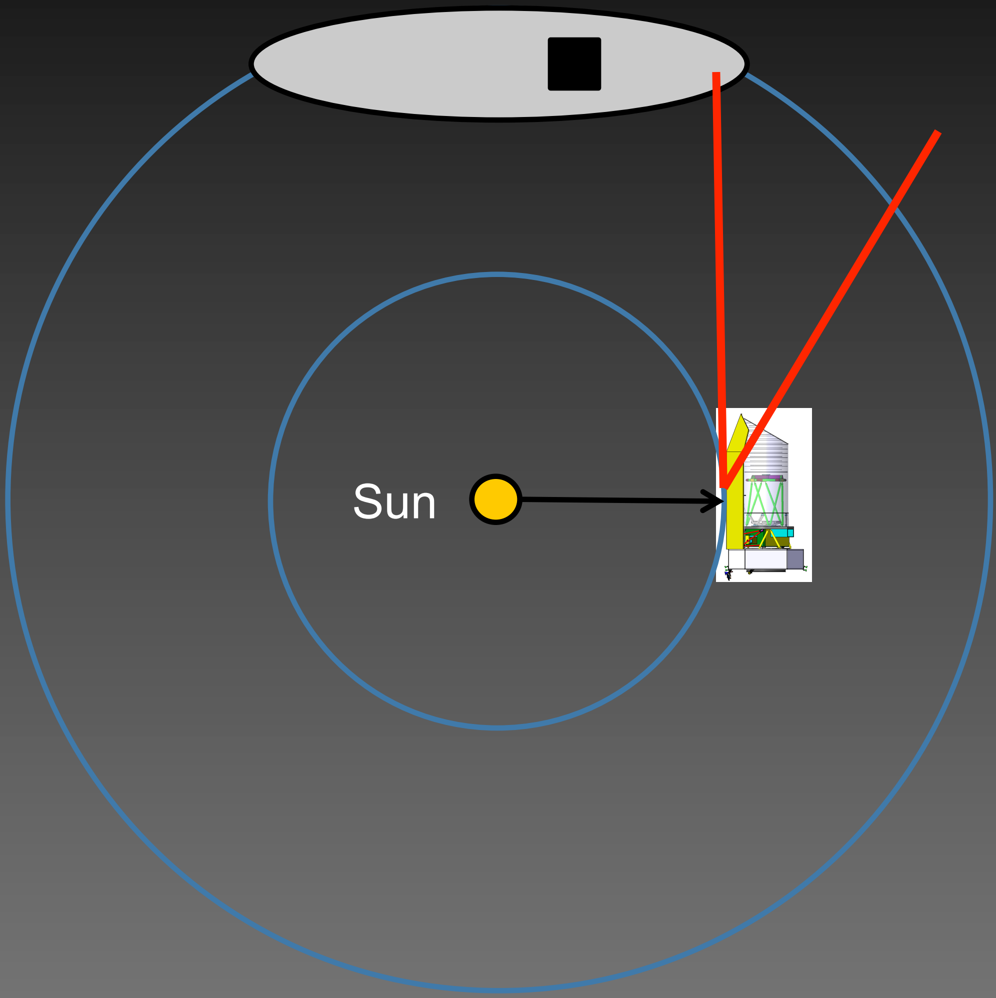

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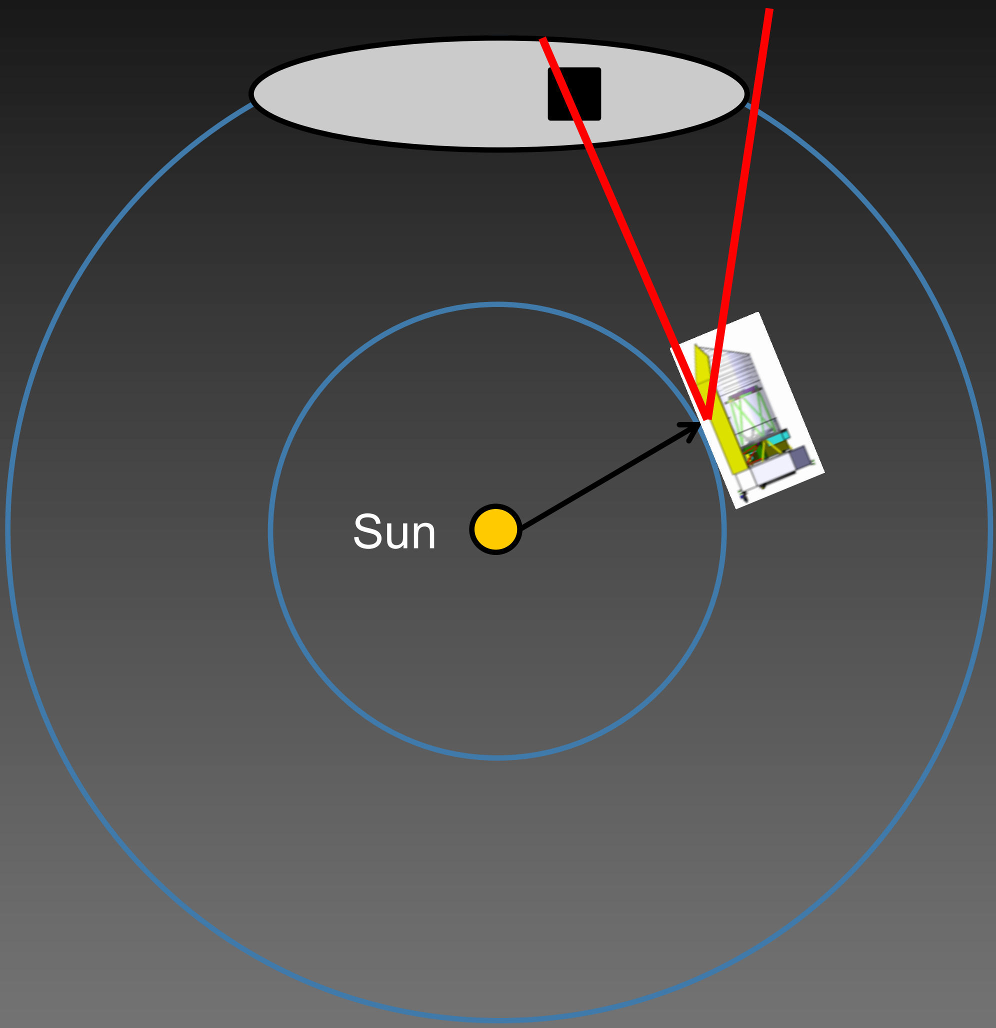

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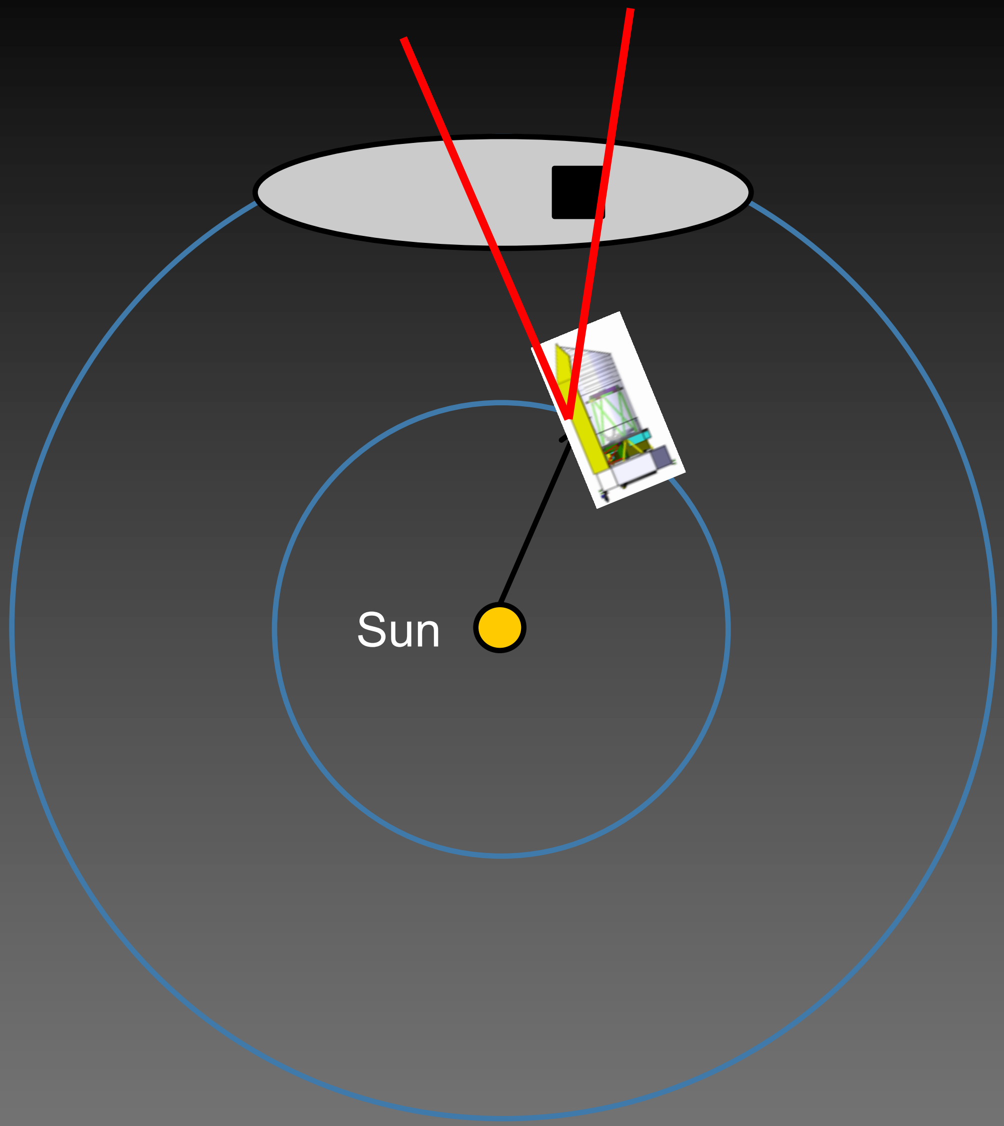

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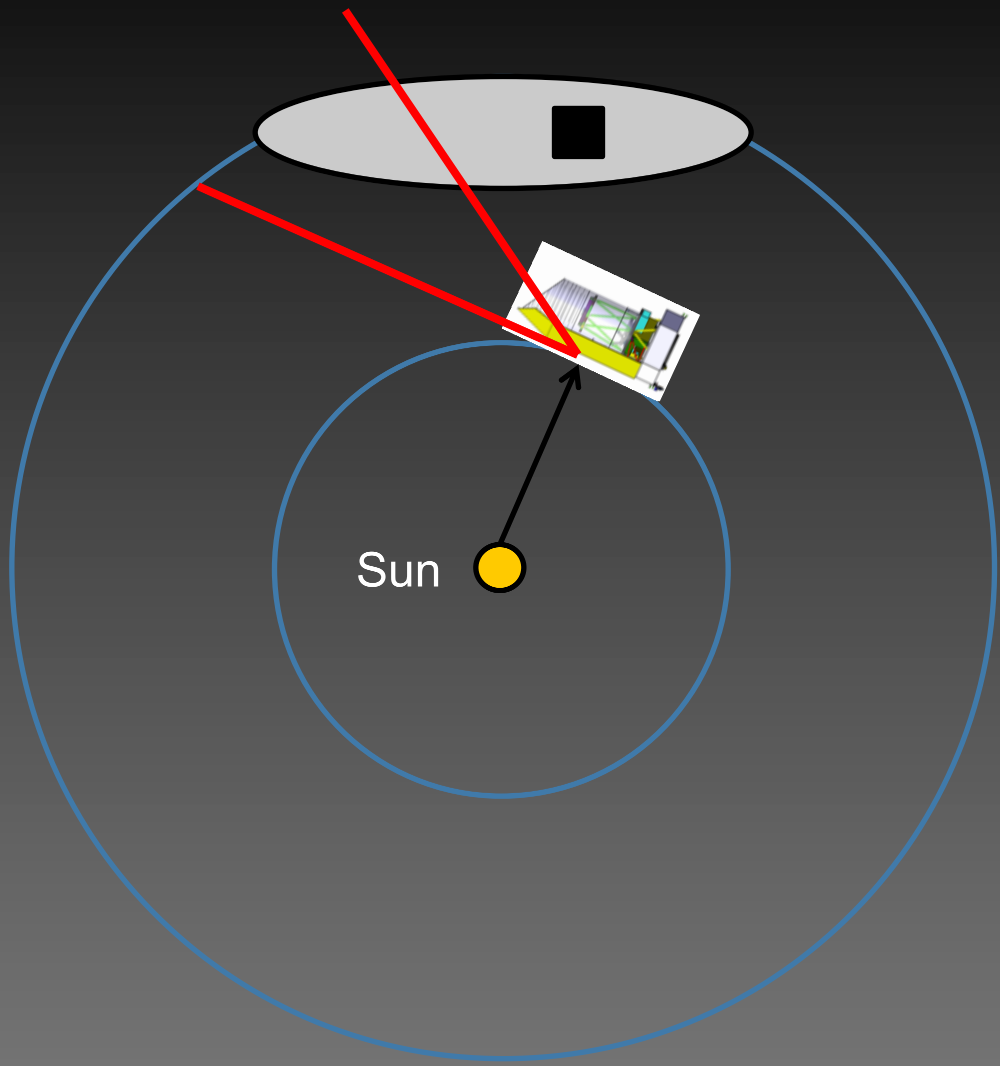

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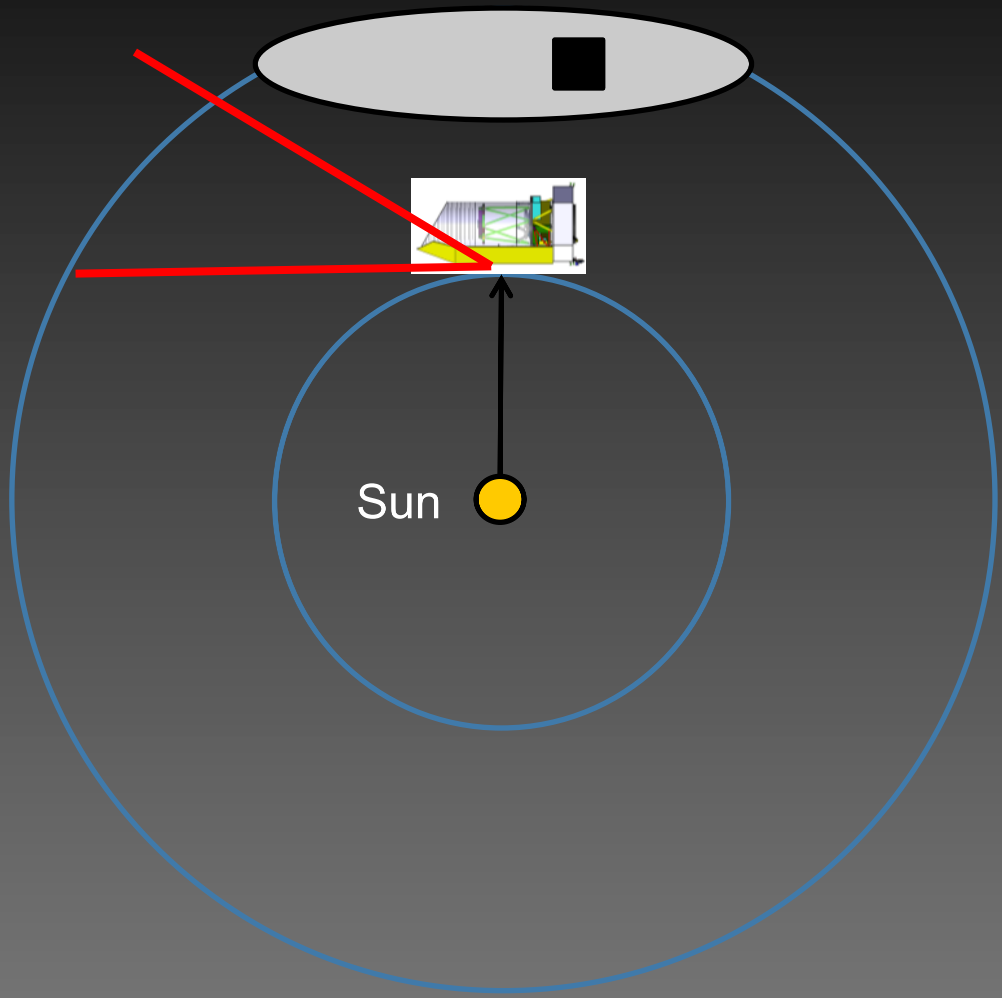

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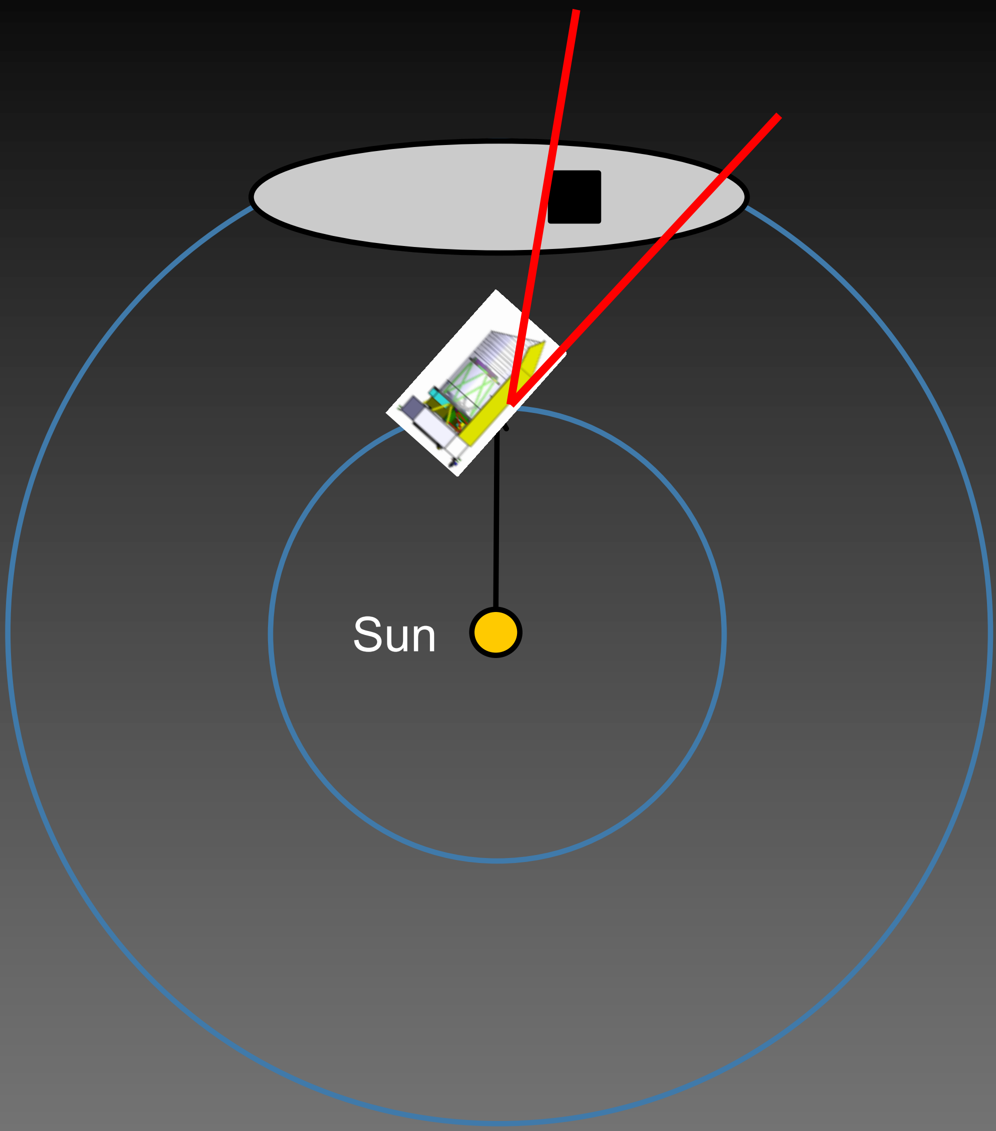

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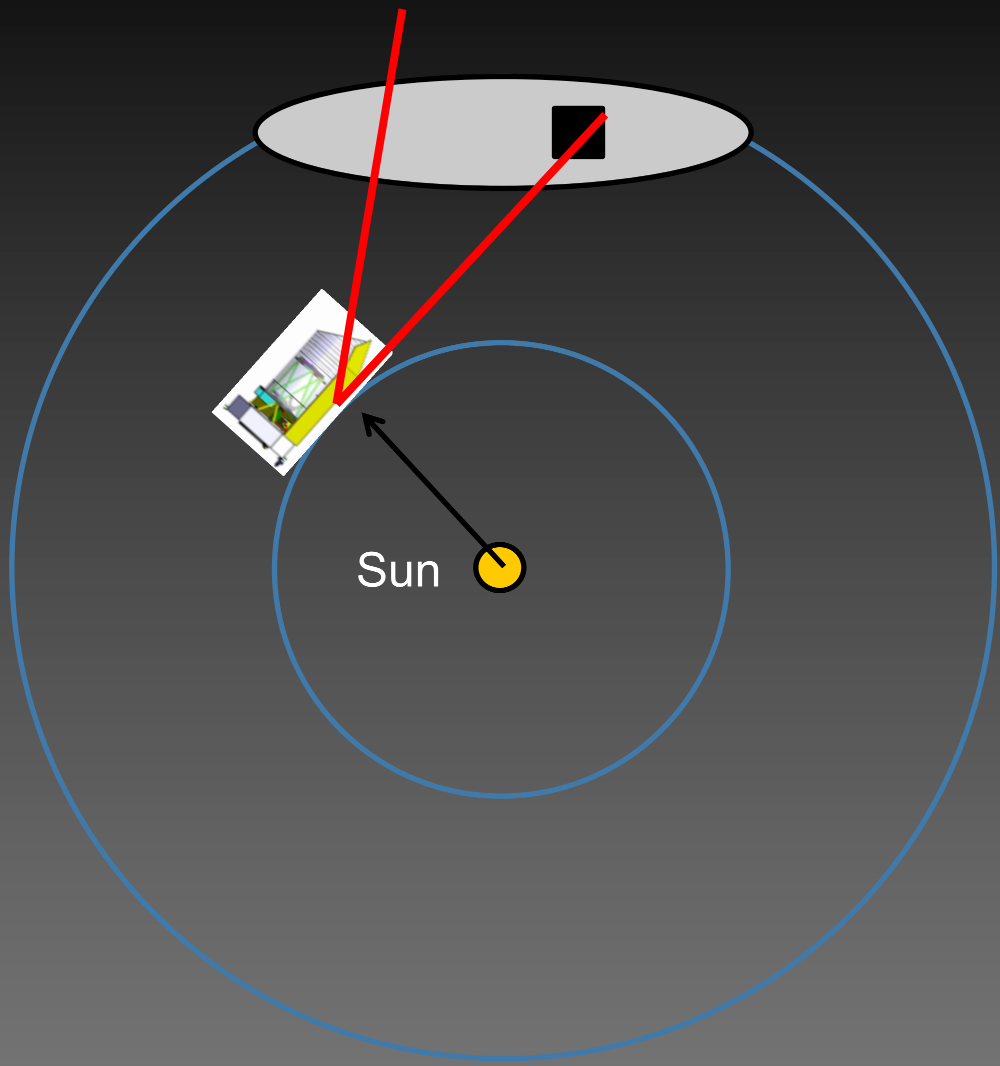

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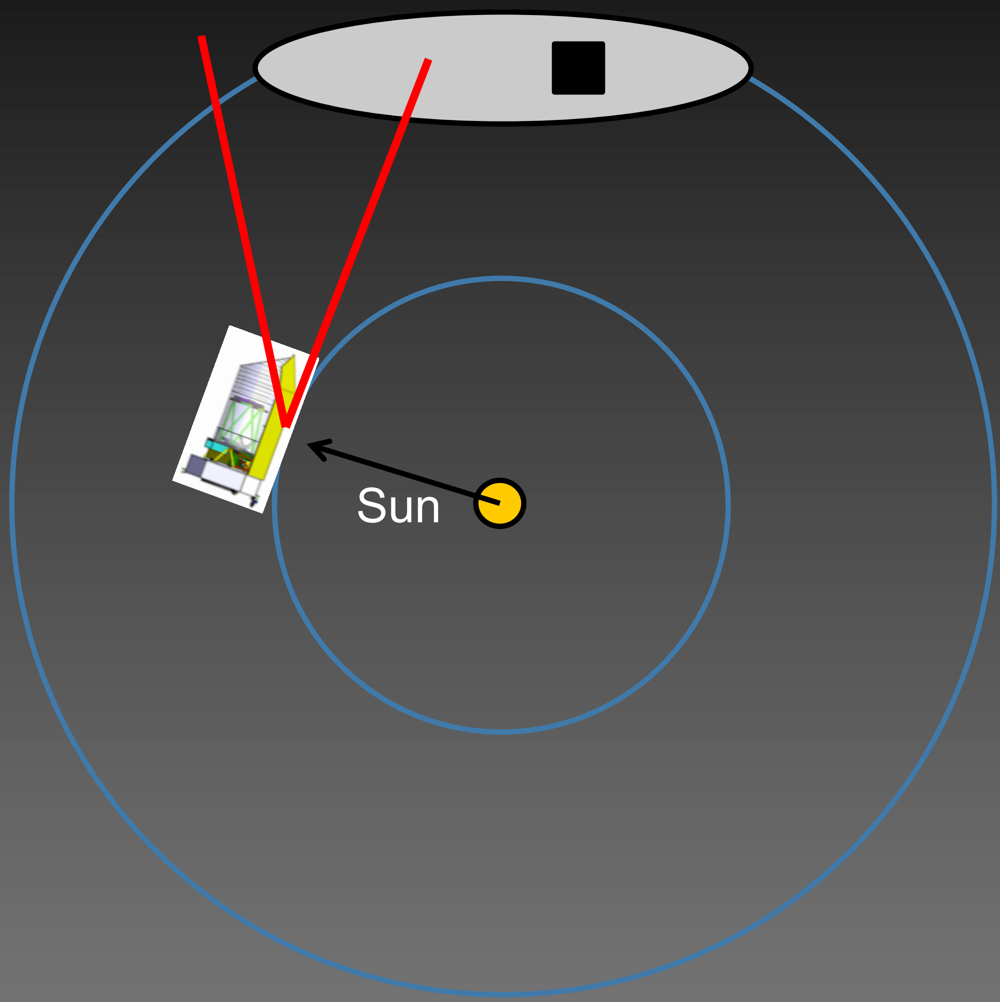


Operation angle from -1 deg to +31 deg.

We can observe for about a month, twice a year.

EUCLID has no contigency for weight : we cannot extend the shielding.

→ Maximum observation : 2 months/year

Some facts

- Legacy Science status (like all non-DE Science)

- Operation angle from -1 deg to +31 deg

- Slew time 350 sec to 150 sec (settling time for IR unknown).
  Probably much better in practice, no official word from ESA

- Maximum observation : 2 months/year

-Implementing Legacy Science surveys with core Science.

--> Simulations + discussions the coming months

EUCLID survey simulation

PhD thesis work of Mathew Penny

Article in prep :

Penny, Kerins, Rattenbury, Robin, Beaulieu MNRAS

Some new calculations will be made very shortly for the paper :
- Updated values of slew times
- Survey in chunks of 1 month instead of 2 month
- Checking the impact of reduced from 2 month to 1 month.
- Potentially adding VISTA data.

MaBμLS simulator

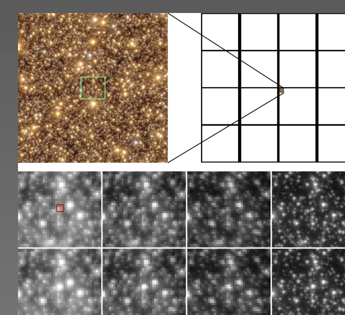
Diameter (m)				1.2
Central blockage (m)				0.4
Slew + settle time (s)				85(285)

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



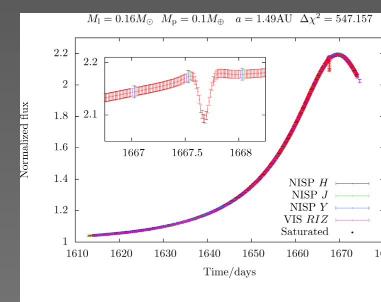
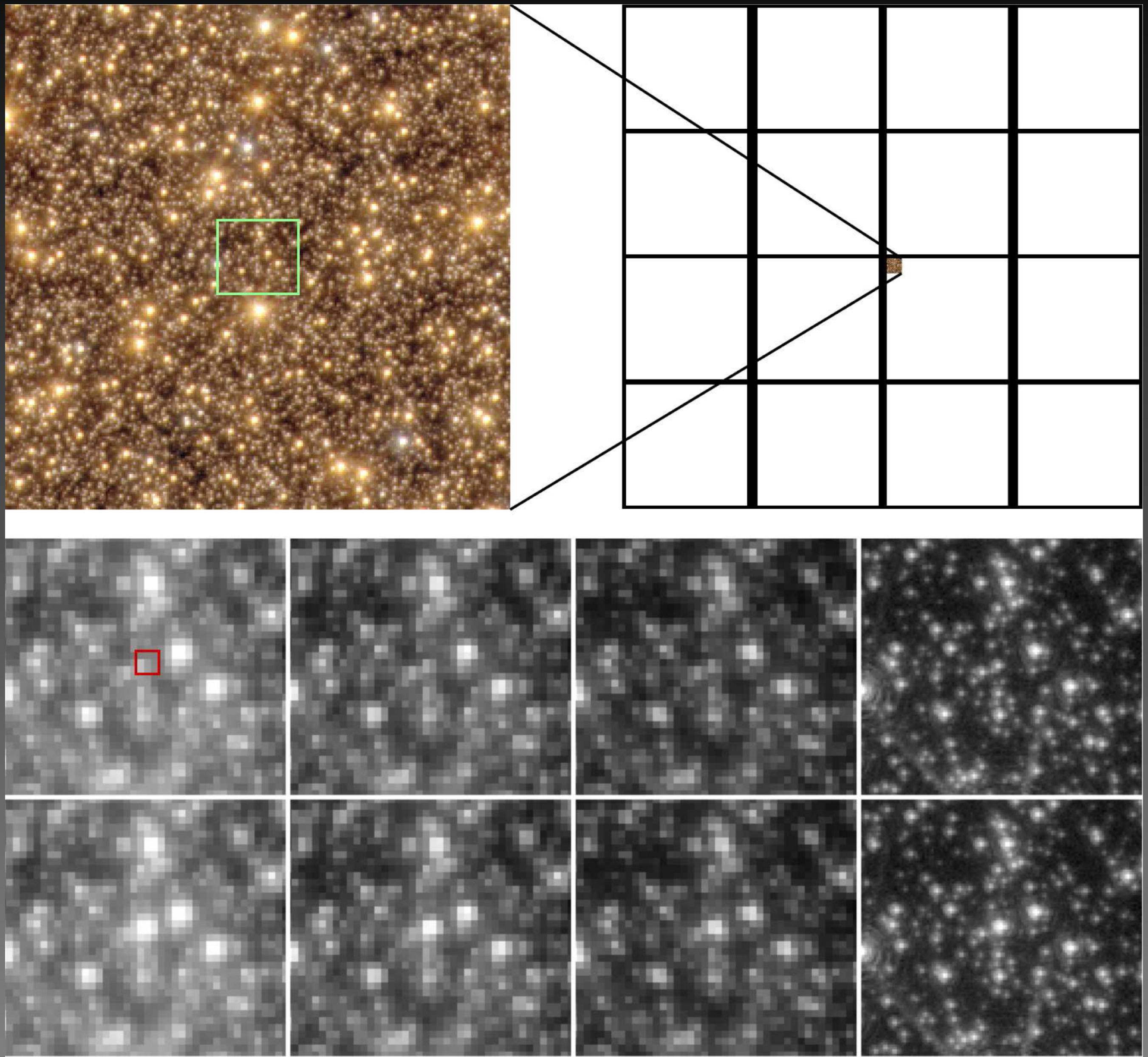


Figure 3. Example lightcurves

Penny, Kerins, Rattenbury, Beaulieu, Robin, 2012, MNRAS in prep
PhD Matthew Penny

Simulated images of galactic Bulge



EUCLID will detect Mars mass planets

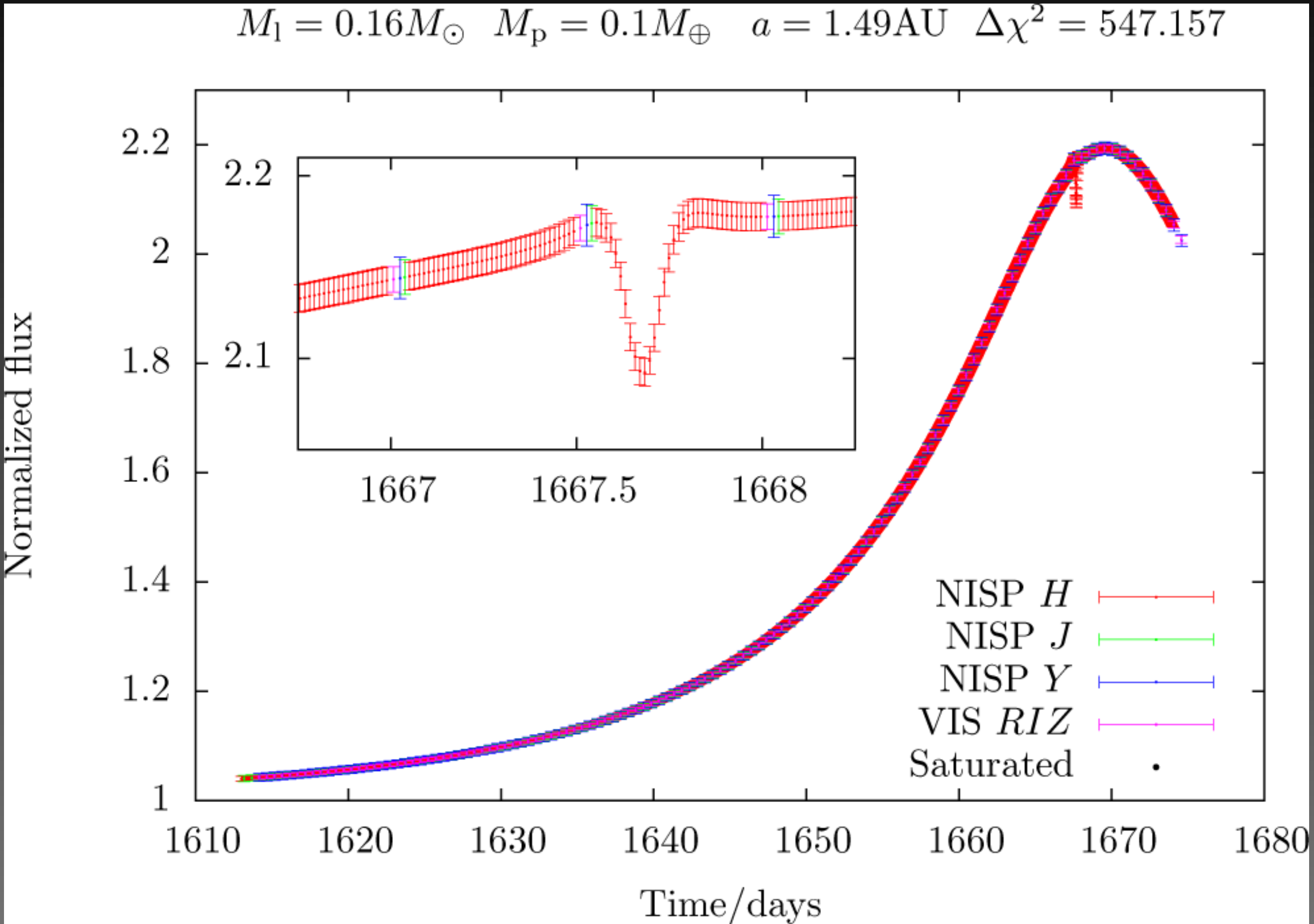
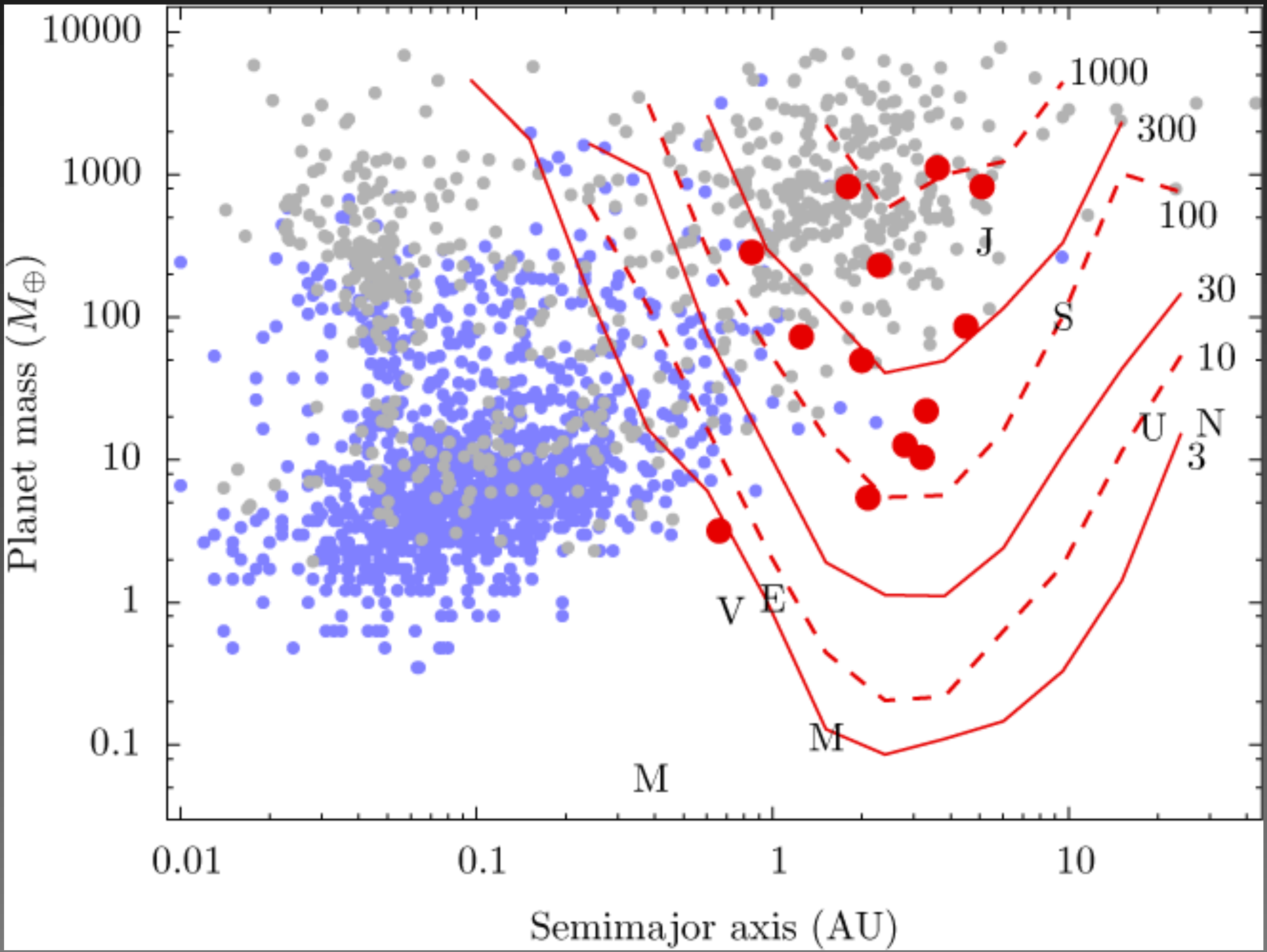
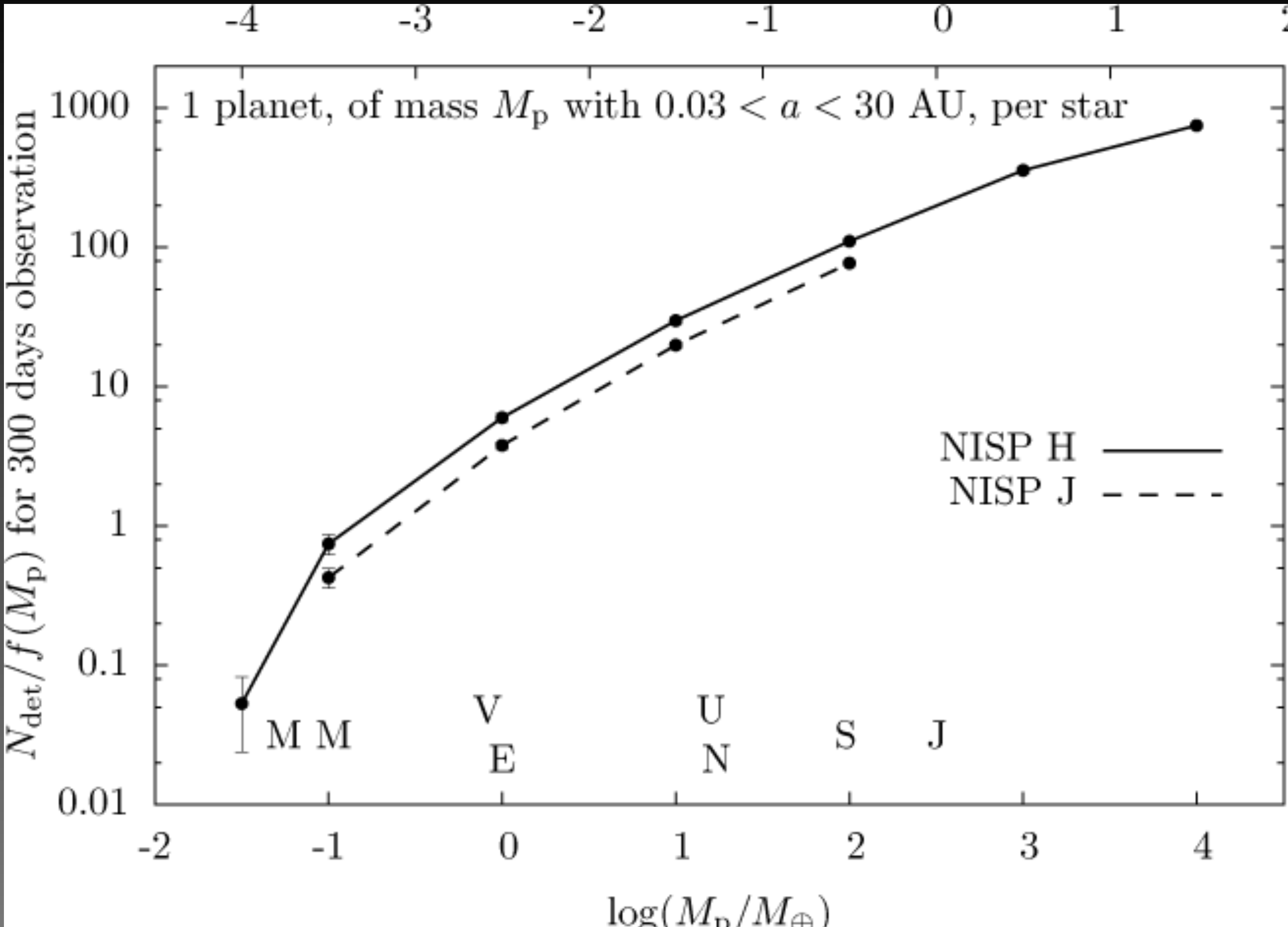


Figure 3. Example lightcurves

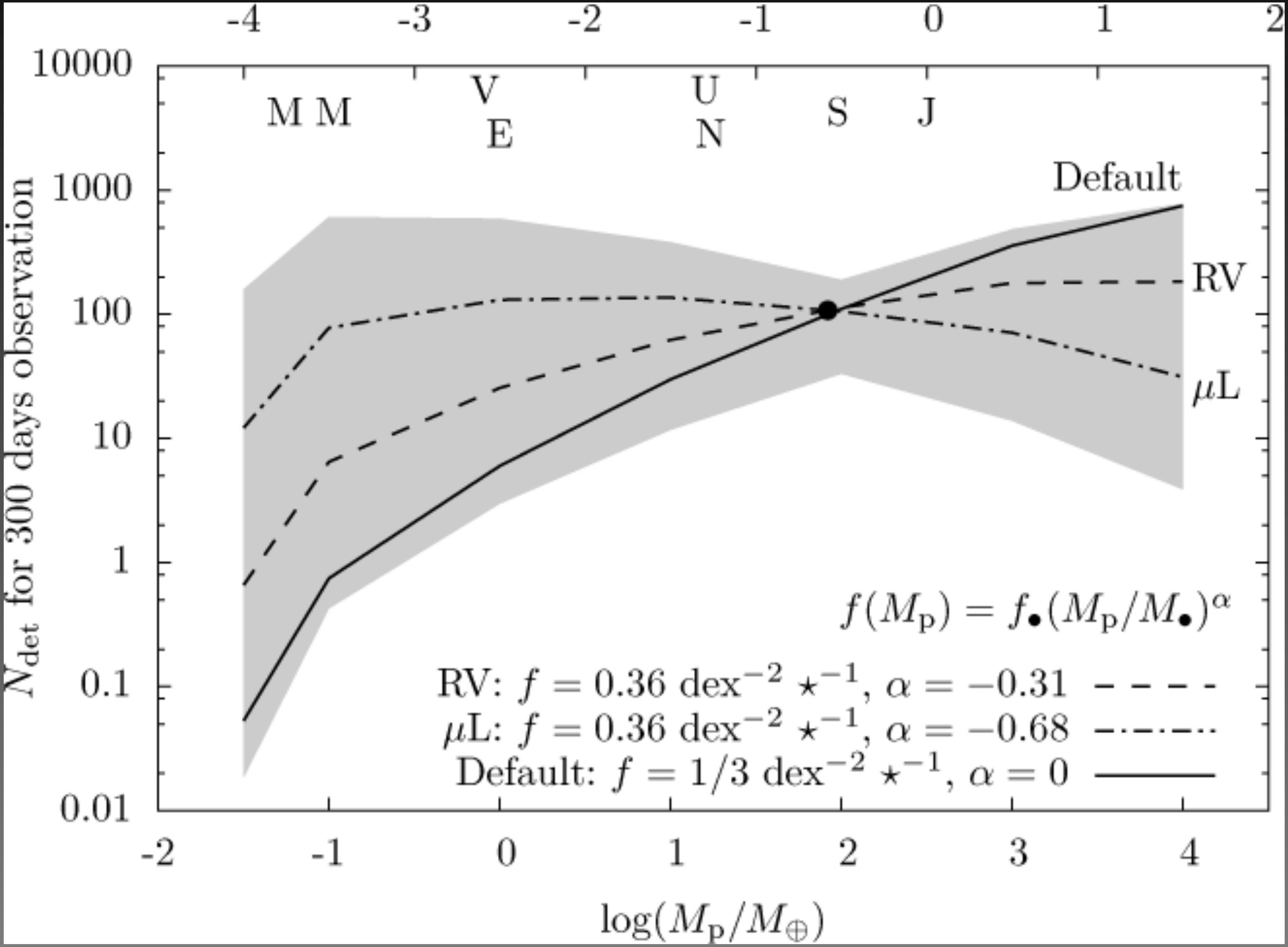
EUCLID planet catch with 5x2 months





-4
-3
-2
-1
0
1
2
1 planet, of mass M_p with $0.03 < a < 30$ AU, per star
1000
100
10
1
0.1
0.01
$N_{det}/f(M_p)$ for 300 days observation
NISP H
NISP J
M M
V
E
U
N
S
J
-2
-1
0
1
2
3
4
$\log(M_p/M_\oplus)$

Measuring the planet mass function



WFIRST science requirements

- A. Make a definitive measurement of the frequency of bound and free-floating planets with masses extending to less than an Earth-mass and separations greater than 0.5 AU.
- B. Measure the masses of the planets and host stars for the majority of the detected exoplanetary systems.
- C. Make a definitive measurement of the frequency of habitable planets

Barry et al., 2011, SPIE paper

WFIRST & EUCLID

In first approximation :
Planet yields vary linearly with focal plane area & observing time

Measuring Mass requires constraining proper motion :
time span and small pixels.
(ask Jay Anderson)

EUCLID VIS (0.1 arcsec pixel) and H (0.3 arcsec pixel)
Need to have observations spread over the mission.

If WFIRST flies in 2025, a survey done in 2020 with EUCLID will help to constraint the masses !

Conclusion I

Microlensing is part of EUCLID Legacy Science
Surveys under studies with Core and Legacy Science (no definitive answer yet)

Rule of thumb : planet yields increases linearly with focal plane area & obs time.

Some EUCLID limitations : operation angle (-1 +30 deg, slew time)

Efficiency of EUCLID Legacy would be greatly increased with US reaction wheels.
We could win time for the surveys !

Early EUCLID microlensing observations will help to constraint the masses for WFIRST.

First census on cold planets down to the mass of Mars & free floating planets with EUCLID (6 months).

A more definite survey and η_{EARTH} with WFIRST (or extended EUCLID).

Conclusion II

There is a lot to do now !

- Ground based optical and IR survey (choosing line of sight)
  - OGLE, MOA, KMTNet, VVV, PLANET
  - 2012+, the era of Wide field imagers !

- Developing better image subtraction pipelines
- Improving modeling software (less pedestrian)

- Obtaining landmark results with current ground based facility
- Transition to wide field imager networks (OGLE, MOA, KMTNeT, PLANET)
- Maintaining follow up facility (uFUN, RoboNET, PLANET, MINDSTEP)

Conclusion III

To improve the efficiency of EUCLID, reaction wheels would be a tremendous improvement that would free time for Core and Legacy Science.