Euclid-Roman joint observation towards the Galactic Bulge

Etienne Bachelet

and

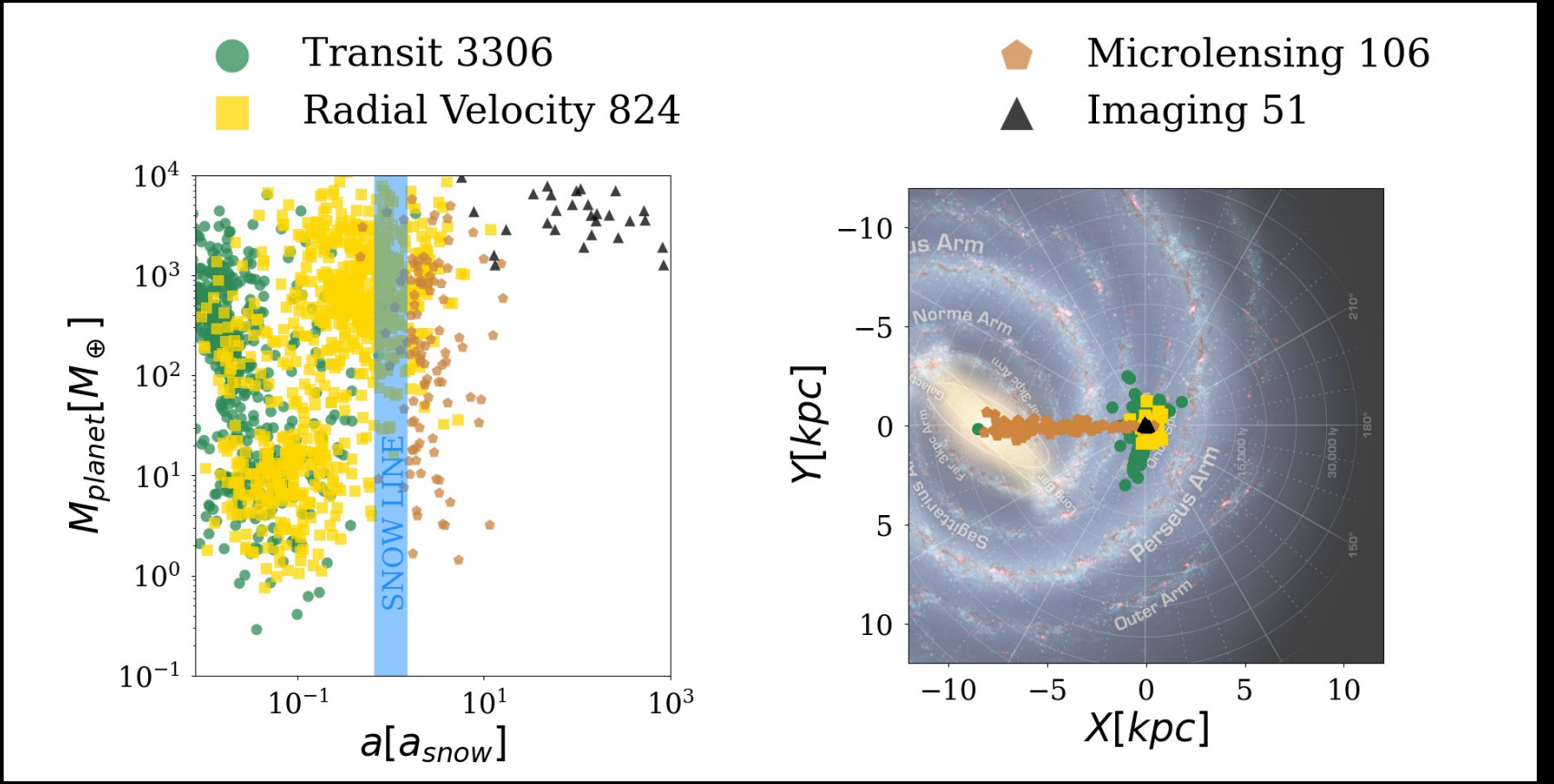
D. Specht, M. Penny, A. A. Nucita, E. Meade, R. Poleski, D. Maoz, J. Rhodes, E. Kerins, M. Hundertmark, J.-P. Beaulieu, S. Awiphan, C. Ranc, M. Dominik, A. C. Robin

NASA grant 80NSSC19K0291

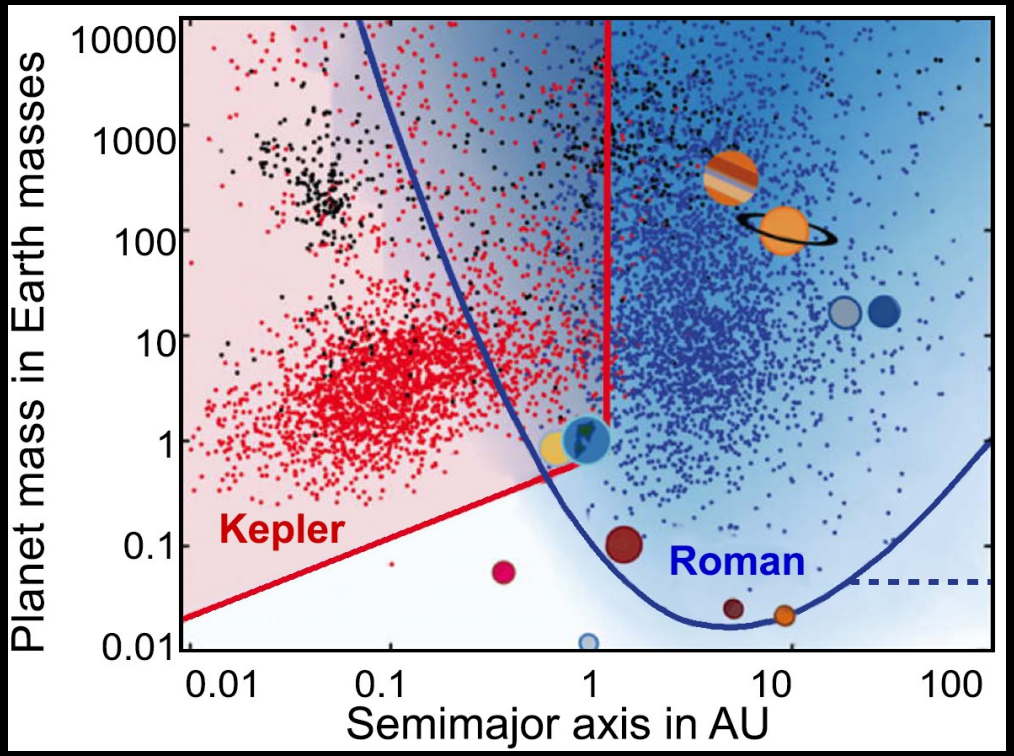
Las Cumbres Observatory

Planet discoveries by methods

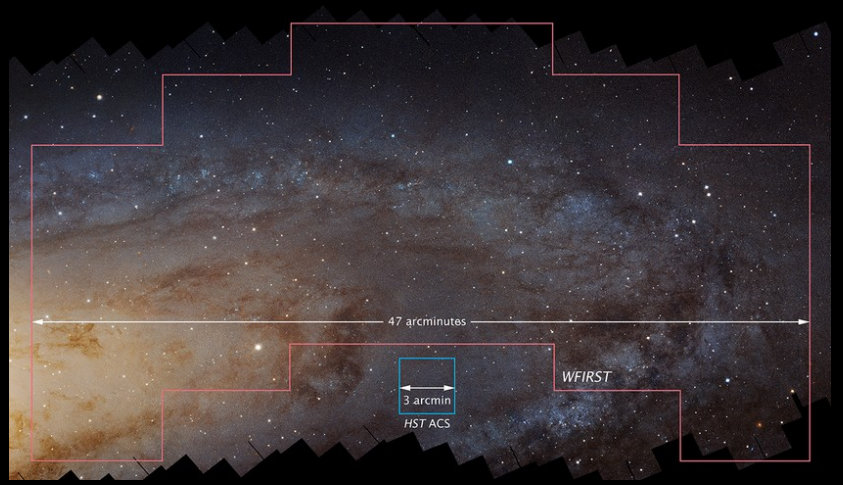
From NASA Exoplanet Archive, 05/02/2021



Roman microlensing survey



Penny et al. 2019, ApJS



- 5 yrs of ~70 d survey of the Bulge
- > 1500 cold planets
- dozens of free-floating planets
- stellar physics, variables ….

Microlensing challenge: the mass and distance degeneracy

- Well measured:
  - **t_E** : Einstein ring crossing time
  - **s** : planet/star separation in Einstein ring radius unit
  - **q** : m_p/m_*, planet/host mass ratio

- It is needed (≥2) extra mass-distance relations

  - **Θ_E:** Einstein ring measurement (finite source effects, astrometric microlensing)
  - **f_l,μ**: lens flux/ relative proper motion (prior/posterior high resolution imaging)
  - **π_E:** microlensing parallax (annual/space based parallax)

Microlensing challenge: the mass and distance degeneracy

- Well measured:
  - $\mathbf{t_E}$: Einstein ring crossing time
  - **s** : planet/star separation in Einstein ring radius unit
  - $\mathbf{q}$: m_p/m_* planet/host mass ratio

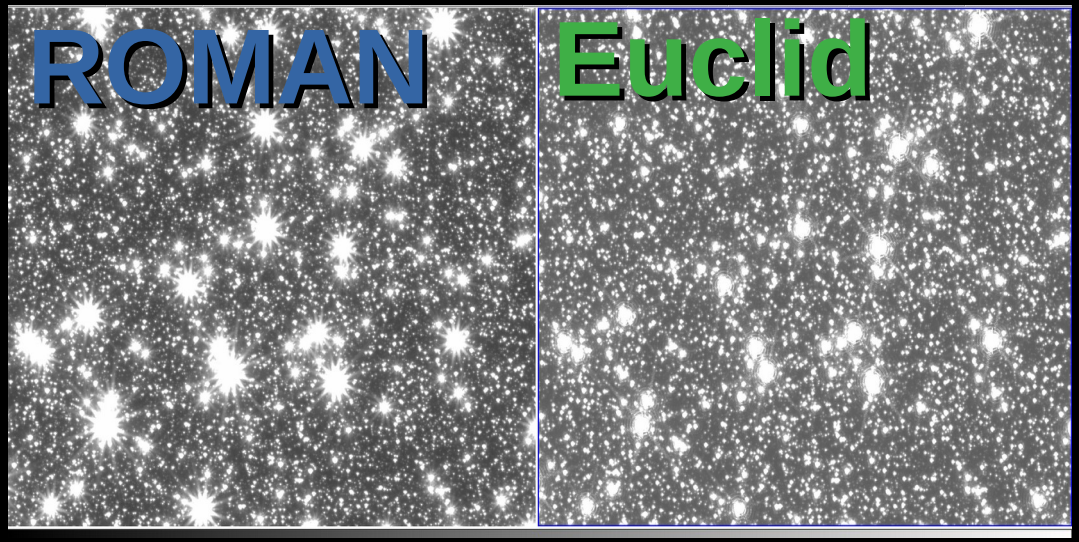
How EUCLID can help?

- It is needed (≥2) extra mass-distance relations

  - $\mathbf{\Theta_E}$**:** Einstein ring measurement (finite source effects, astrometric microlensing)
  - $\mathbf{f_l}$**,**$\boldsymbol{\mu}$: lens flux/ relative proper motion (prior/posterior high resolution imaging)
  - $\boldsymbol{\pi_E}$**:** microlensing parallax (annual/space based parallax)

Euclid possibilities

1. Early survey of Roman fields



432 events simulated

1 Euclid image at MJD ~ 58916

2 ROMAN images at
MJD ~ 61044 , 62325

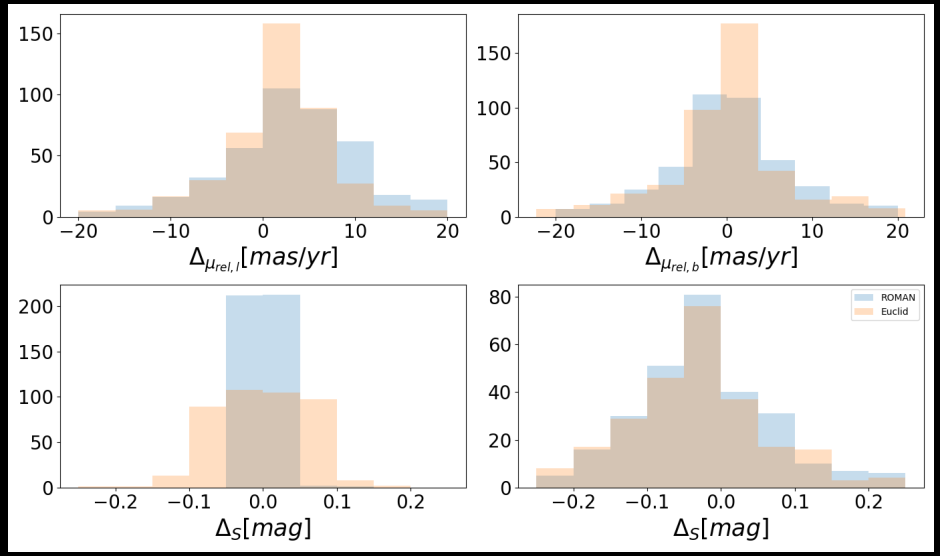
Fits parameters :

- Lens/Source magnitudes
- Lens/Source proper motions

Euclid possibilities

1. Early survey of Roman fields

|Fit-Input|	ROMAN	Euclid
$\|\Delta\mu_l\| \leq 1$ mas/yr	7%	13%
$\|\Delta\mu_b\| \leq 1$ mas/yr	17%	28%
$\|\Delta S\| \leq 0.1$mag	99%	93%
$\|\Delta I\| \leq 0.1$mag	47%	41%



Bachelet et al. A&A under review

Euclid possibilities

1. Early survey of Roman fields

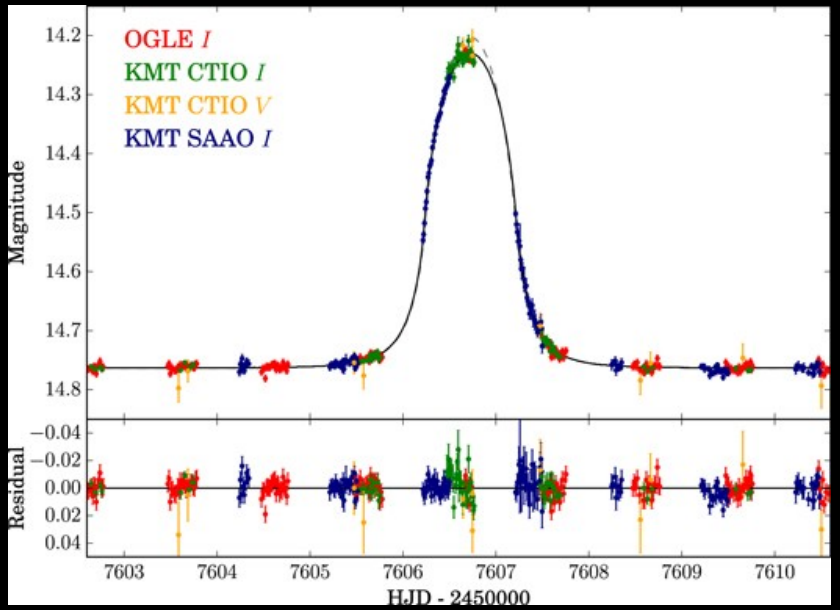
If the Roman target field is 2 square degrees, we need four Euclid pointings (16 dither images, each with a 300s exposure time) to cover it, **about 7 hours of Euclid time**, as early as possible and get :

- Lens source/proper motions in > 10% cases
- Lens and sources fluxes in > 40 % cases

This will **guarantee a mass measurement** for a significant fraction of planets from **year 1** of the Roman microlensing survey.

Euclid possibilities

2. Simulatenous observations to hunt free-floating planets and planets on wide orbits



Jupiter-mass in the disk

OR

Saturn-mass in the Bulge

Mróz, P. et al, AJ, 2018

Simulatenous Euclid-Roman observations can constrain the parallax of these systems ! (see *Bachelet and Penny, APJL, 2019)*

Euclid possibilities

2. Joint observations to hunt free-floating planets and planets on wide orbits

- We simulated ~10^{11} unique lens/source pairs using the Besancon model (*Robin et al. 2012*)

- Generate Roman and Euclid lightcurves

- Apply vary criterion for detection of :

  - the event (S/N)
  - the parallax π_E at 5 σ (*Bachelet and Penny, APJL, 2019*)
  - finite source effect, i.e. Θ_E

Euclid possibilities

2. Joint observations to hunt free-floating planets and planets on wide orbits

2 Jupiter-mass FFP per MS

FFP Model	Filter Combination	S/N only	S/N + Parallax	S/N + Finite Source	All Constraints
Sumi (2011)	W146 + VIS	490	450	18	18
	W146 + NISP (H)	490	450	19	19
Mróz (2019)	W146 + VIS	130	110	28	28
	W146 + NISP (H)	130	110	31	31

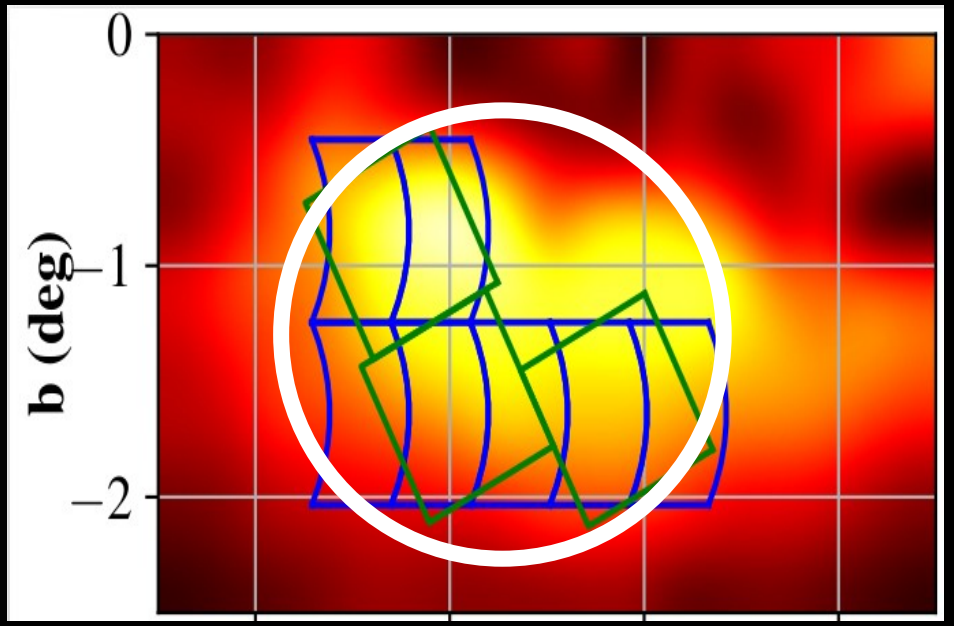
10 Earth-mass FFP per MS

Bachelet et al. A&A under review

THANKS!

Euclid unique possibilities

Bachelet et al. A&A under review



ROMAN EUCLID RUBIN

	ROMAN	Euclid	Rubin
λ	[0.6,2] μm	[0.6,2] μm	SDSS u,g,r,i + z (~0.85 μm) + y (~1 μm)
FOV	0.3 deg^2	~0.53 deg^2	3.5 deg^2
Resolution	0.11 mas/pix	0.1,0.3 mas/pix	0.2 mas/pix
Limit mag	~27 mag	~25 mag	~27 mag
First light	~2025	~2022	~2023

Euclid possibilities

2. Joint observations to hunt free-floating planets and planets on wide orbits

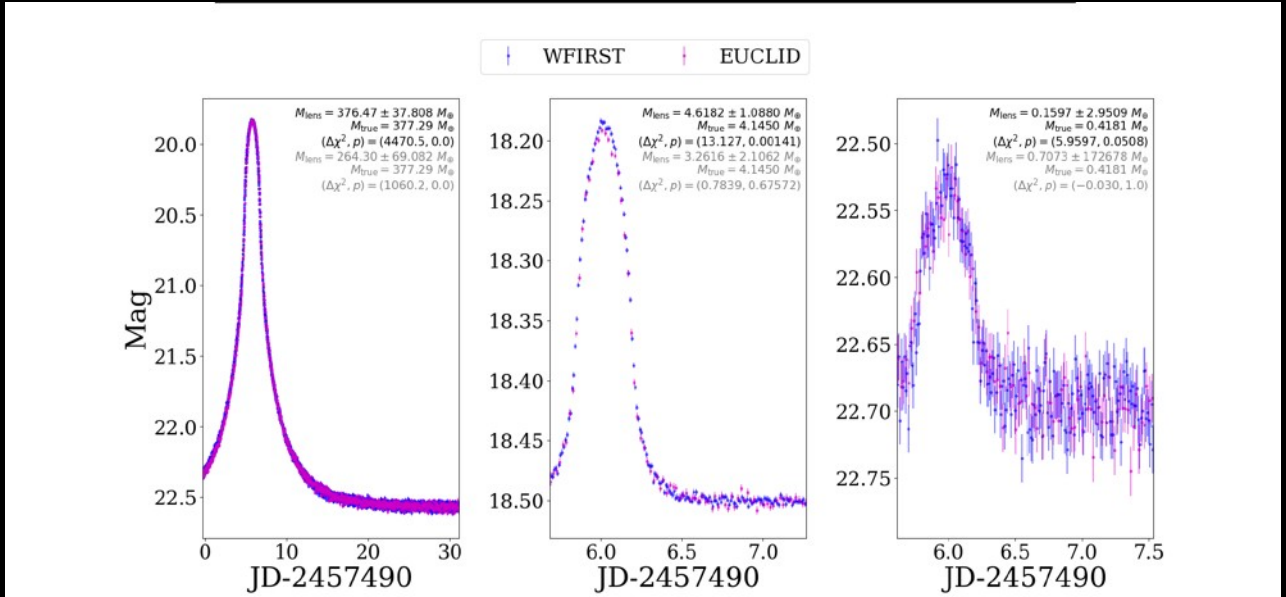


Fig. 1. Three simulated examples of microlensing events due to FFP lenses as seen by EUCLID and ROMAN. Best-fit parameters based only on ROMAN data are presented in gray in the top-right of each figure, while shown in black are best-fit solutions using both datasets. Note that the shifts in time and magnification due to the parallax are too small to be visible. Magnitudes are artificially aligned to the ROMAN system for the plotting.

Bachelet et al. A&A under review