Optimizing space-based microlensing exoplanet surveys

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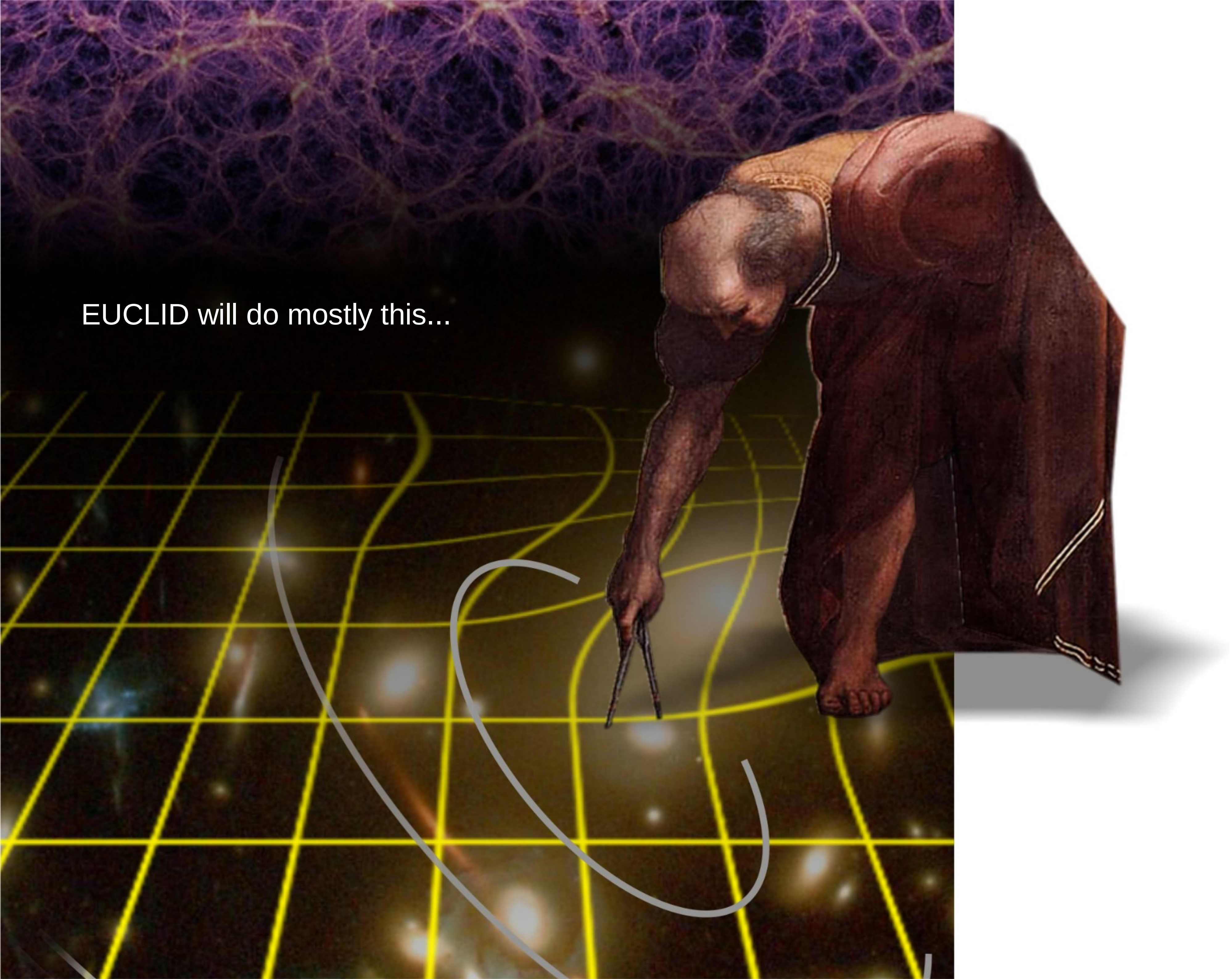
Microlensing and exoplanets

- Kepler transit mission is blazing a trail for hot and warm exoplanets. Approaching the habitable zone from the hot exoplanet regime
- Microlensing is the only available method to access the cold exoplanet regime with comparable sensitivity to Kepler.
- Approaches the habitable zone from the other end of the exoplanet discovery space: minimizes the exoplanet detection blind spot (around the habitable zone)
- Microlensing can inform planet formation theories better than any other detection method as it probes the region where most planets are predicted to form
- Microlensing from space is needed to get statistics of cold Earth-mass exoplanets as their signals are normally washed out from the ground.

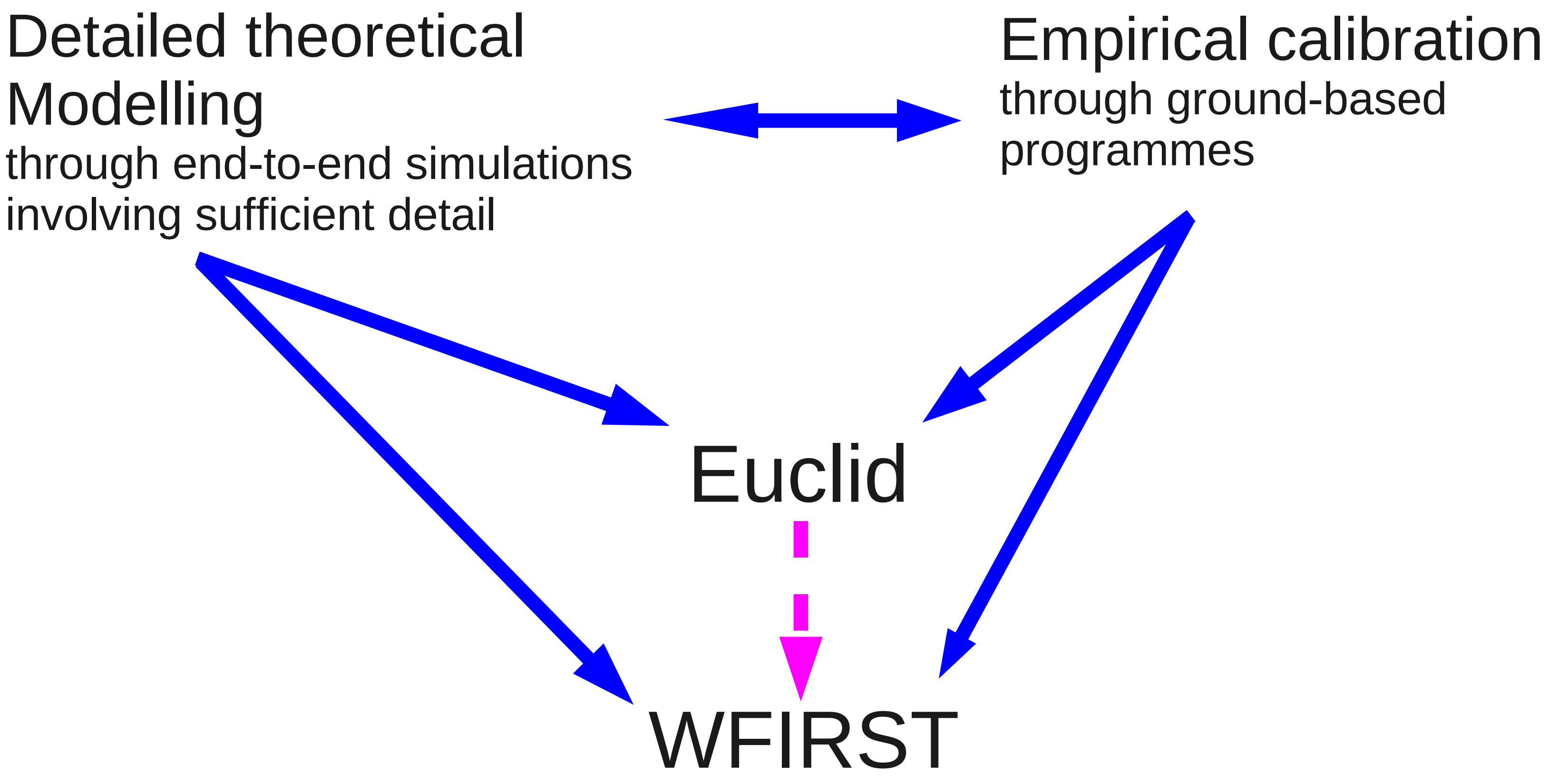

EUCLID will do mostly this...


...but could also do a bit of this!

Microlensing and Euclid

- Euclid: the first cosmology mission with an Exoplanet Working Group
- Microlensing is **not** part of the core science **but is** specified in the ESA Red Book (Laureijs et al 2011) as a possible additional science activity.
- Cannot set requirements on the mission, but anyway much less demanding than weak lensing
- Euclid will spend up to 2 months/year looking in the Galactic plane and unable to do primary science
- Angle of regard for Euclid is up to 30 deg for exoplanet observing: one month of continuous bulge observations is possible.
- **Exoplanets can keep Euclid busy when cosmology can't**
- **Euclid won't compete with WFIRST for exoplanet catch but an effective exoplanet programme aboard Euclid is useful for WFIRST exoplanet science**

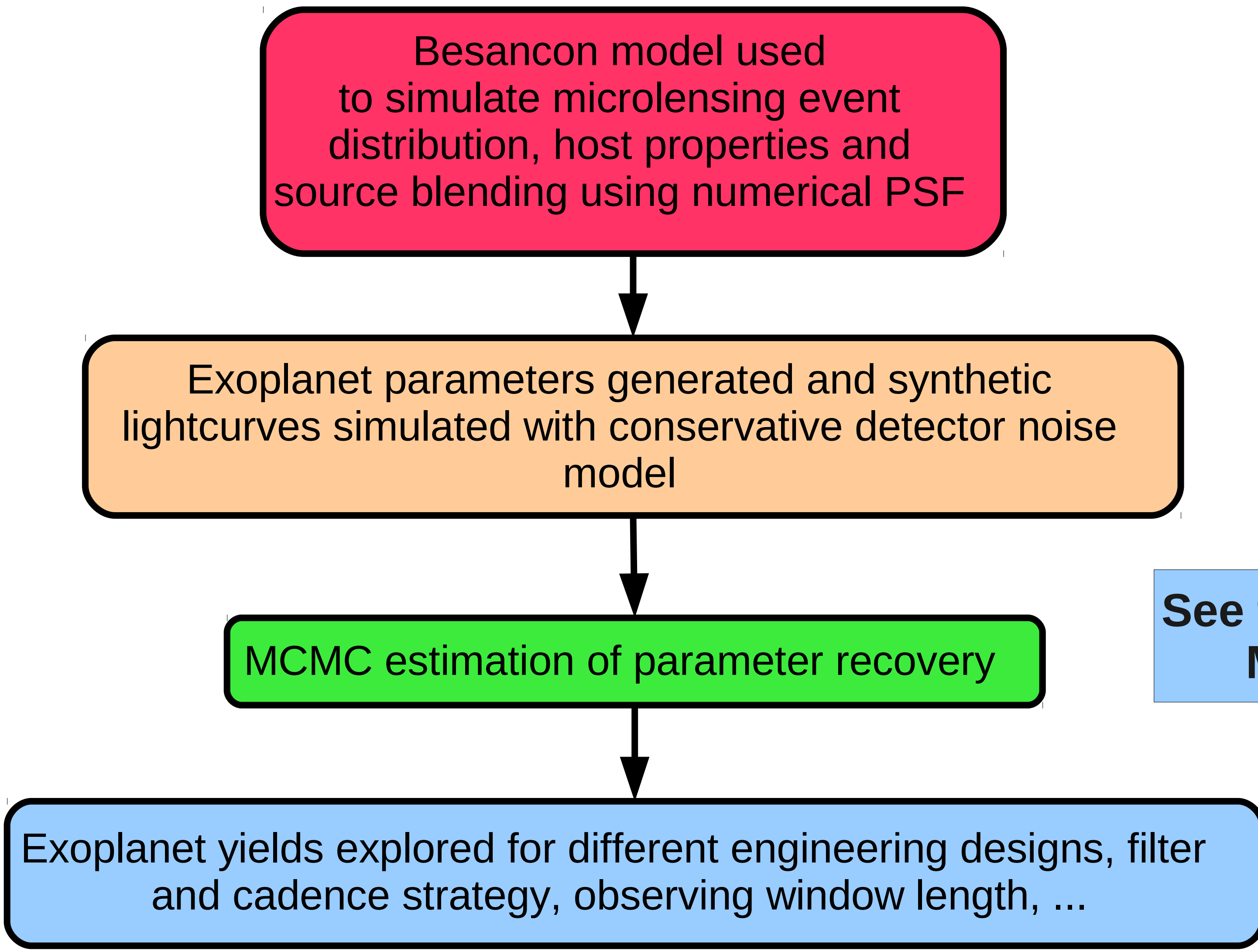
Optimization roadmap



If WFIRST is launched after Euclid, early Euclid microlensing data will be the best possible optimizer for the WFIRST exoplanet programme

Theoretical modelling

MaBuLs: Manchester – Besancon microlensing simulator
End-to-end simulator of exoplanetary microlensing (Penny, Kerins et al, in prep)



See tomorrow's talk by Matthew Penny

Where to look

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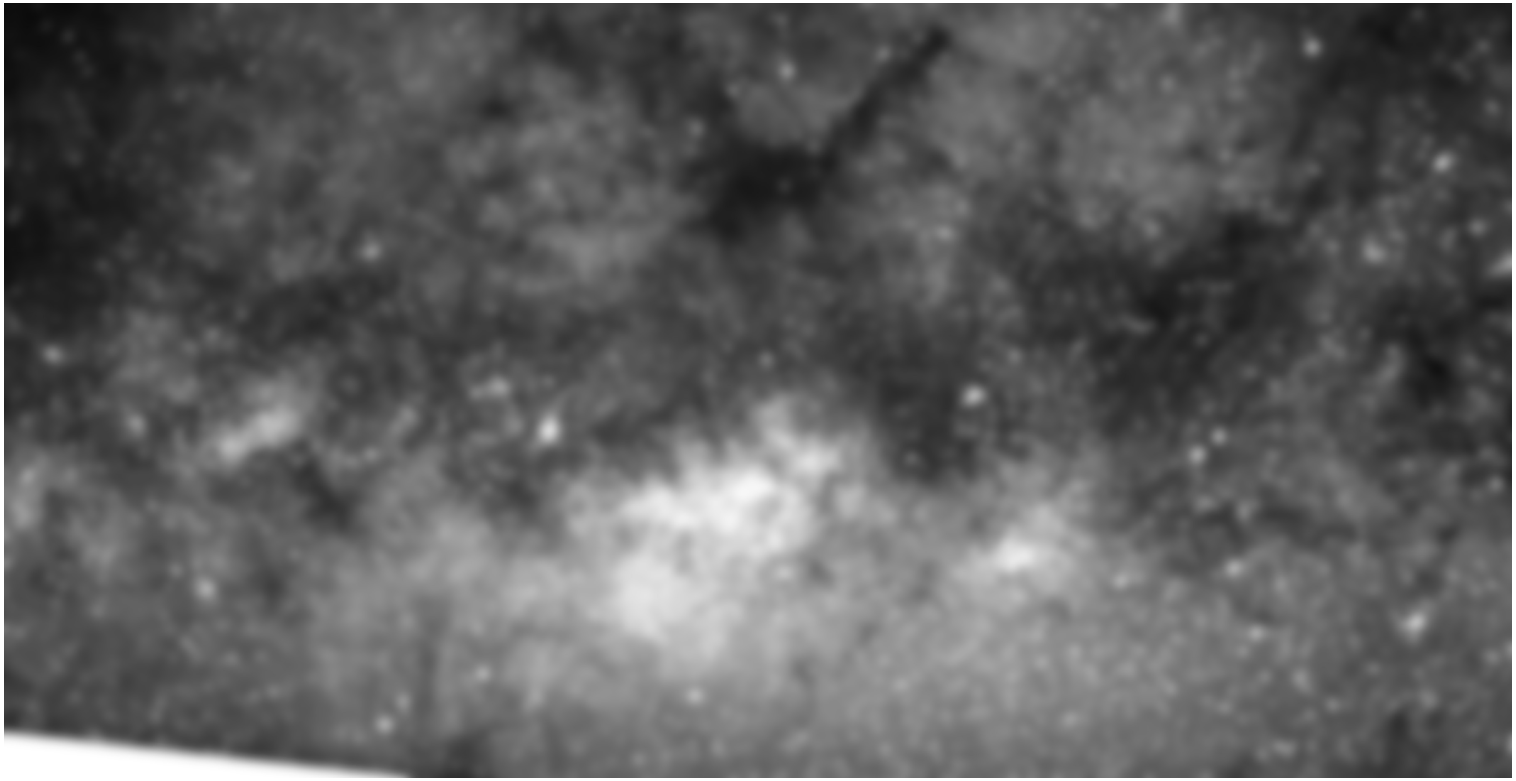

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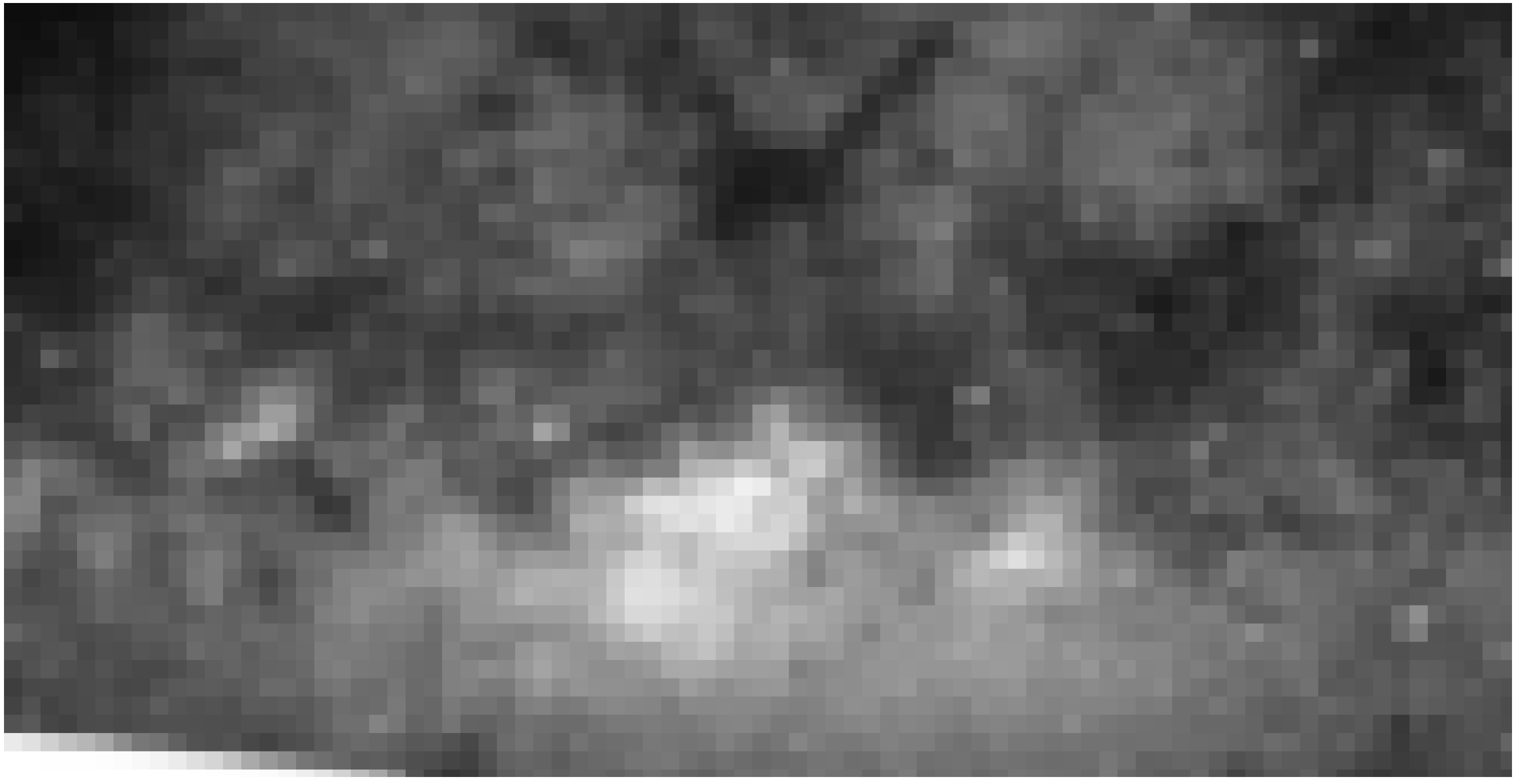

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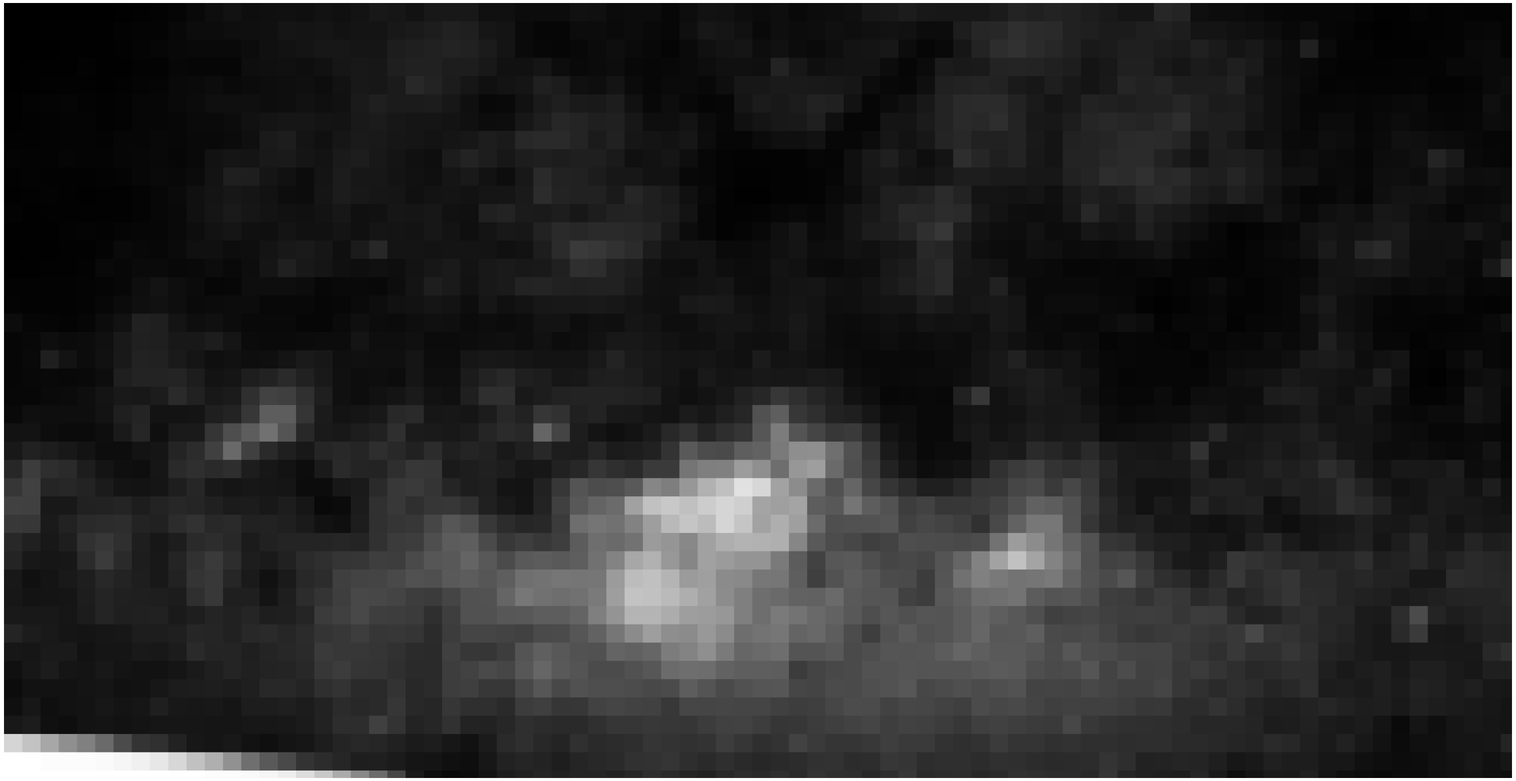
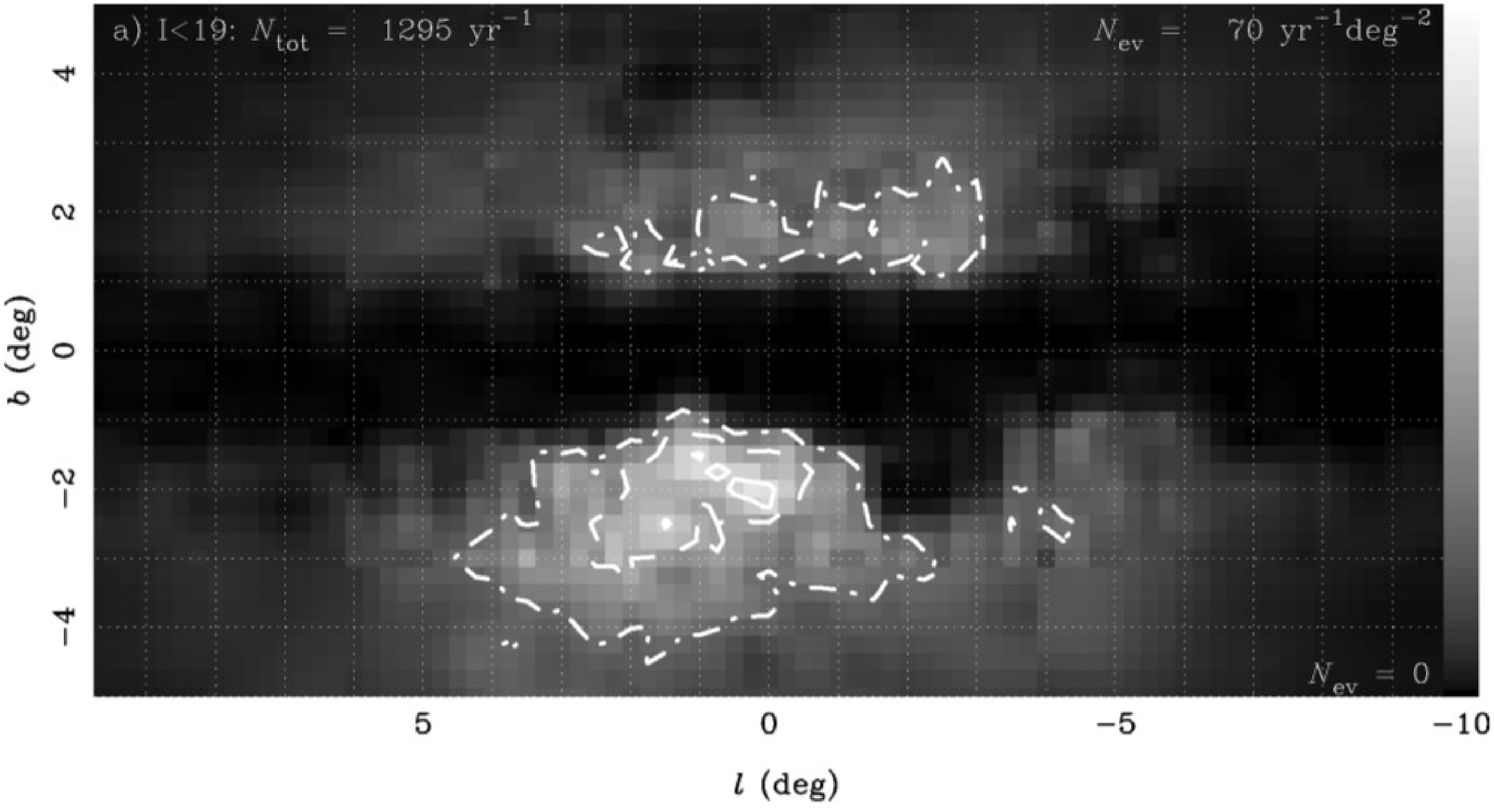


How to look

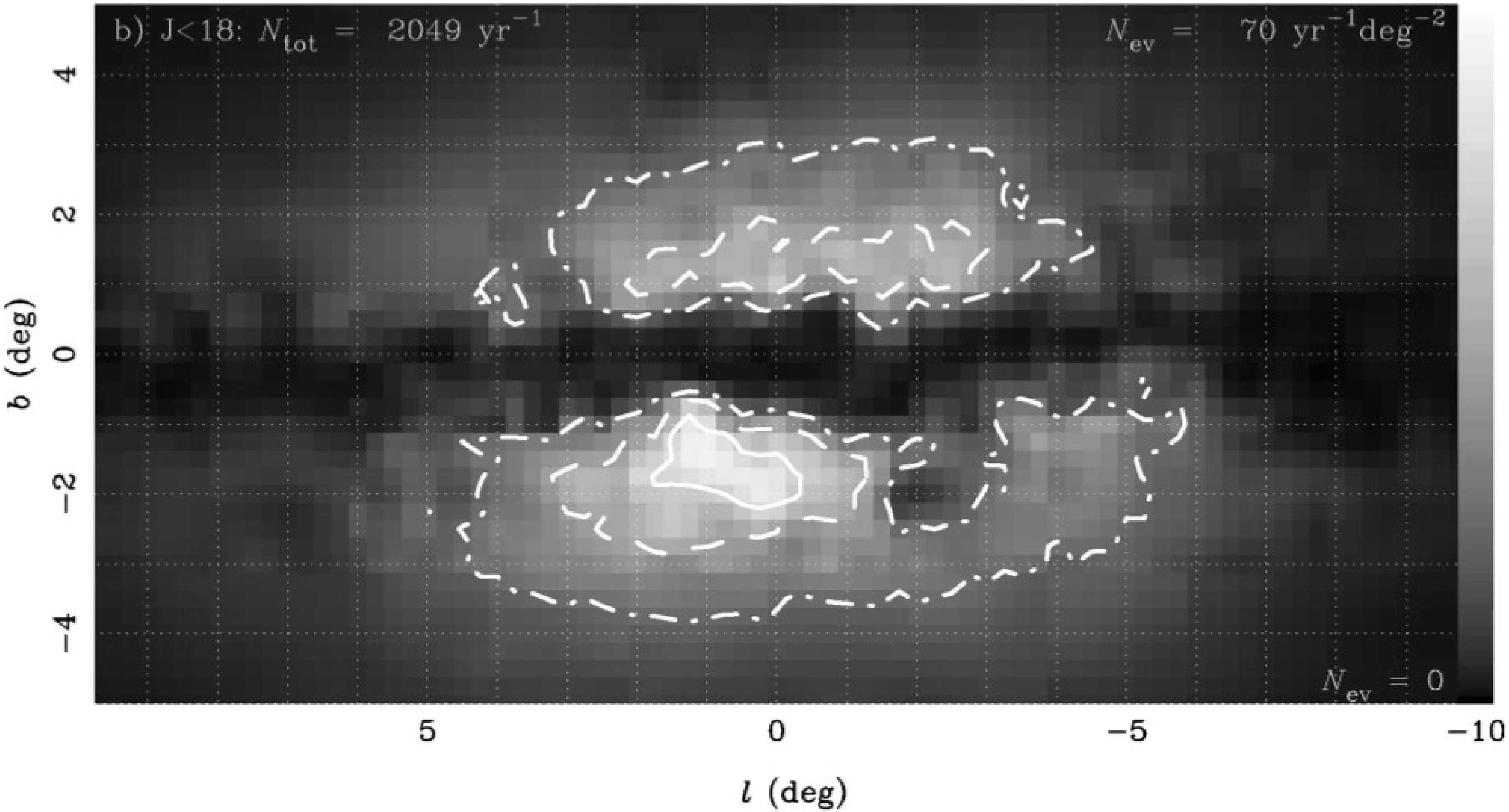
The Galaxy by microlensing light: I band



Microlensing simulations using the Besancon population synthesis Galactic model (Kerins, Robin & Marshall 2009)

How to look

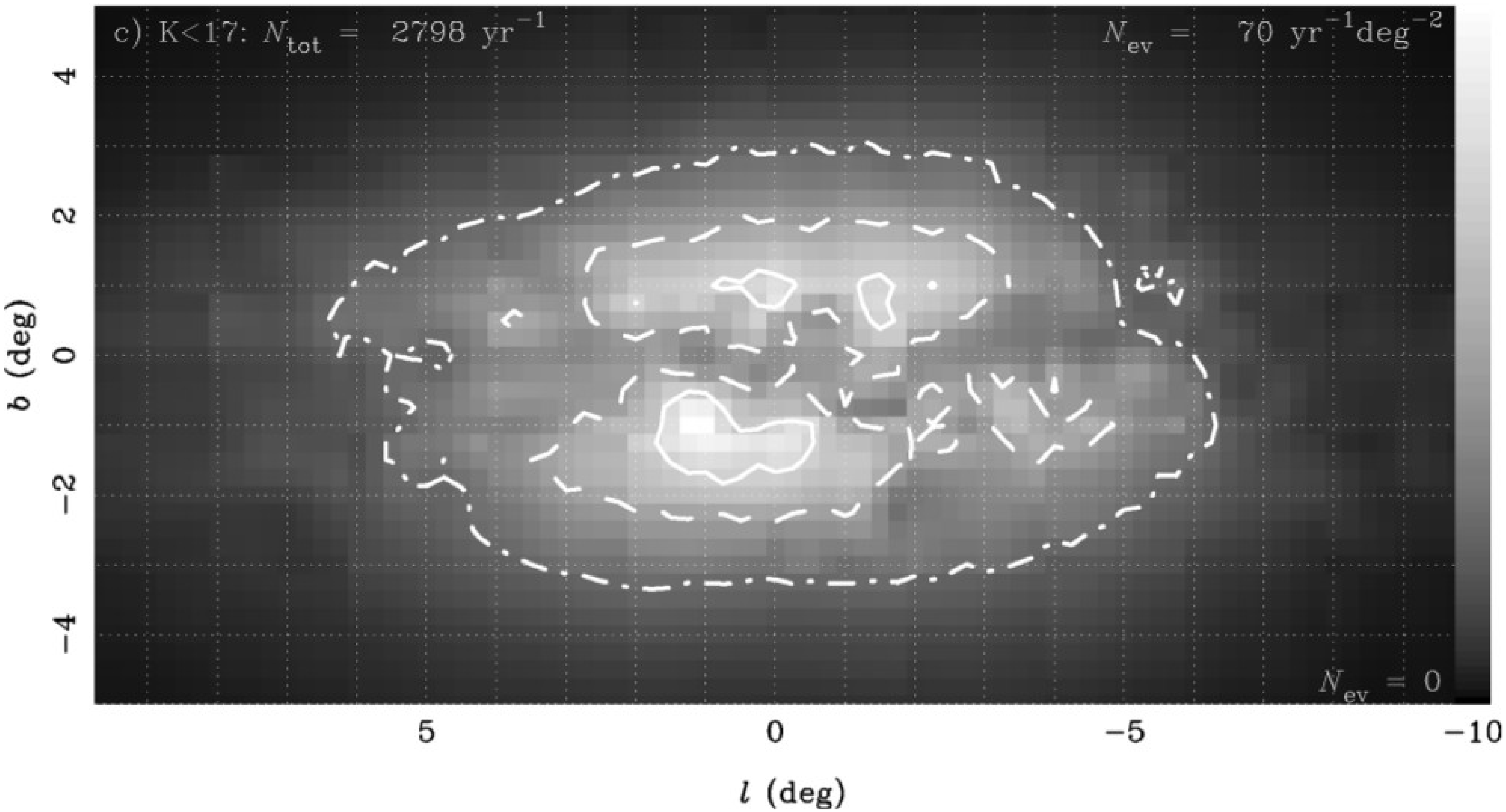
The Galaxy by microlensing light: J band



Microlensing simulations using the Besancon population synthesis Galactic model (Kerins, Robin & Marshall 2009)

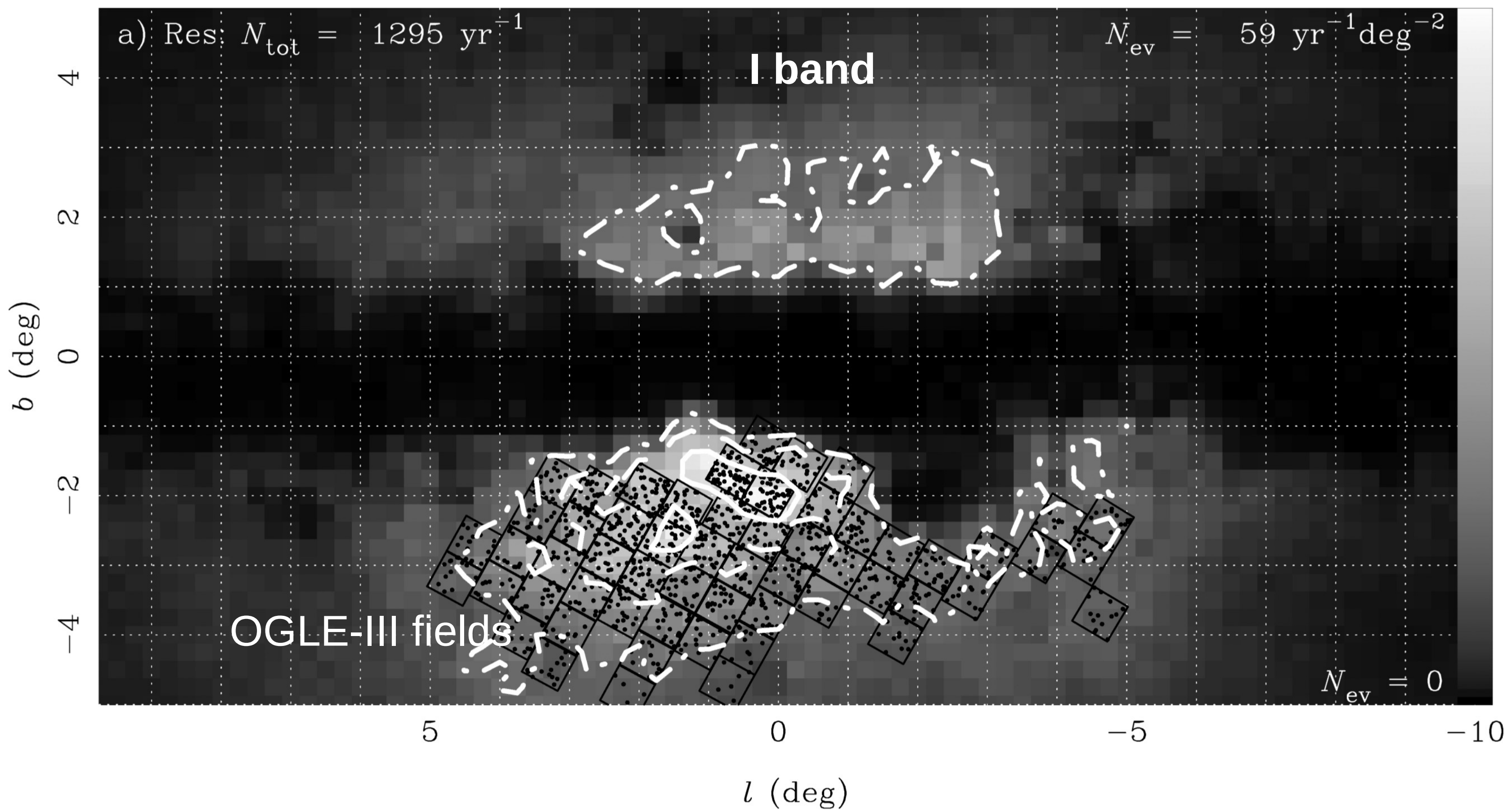
How to look

The Galaxy by microlensing light: K band

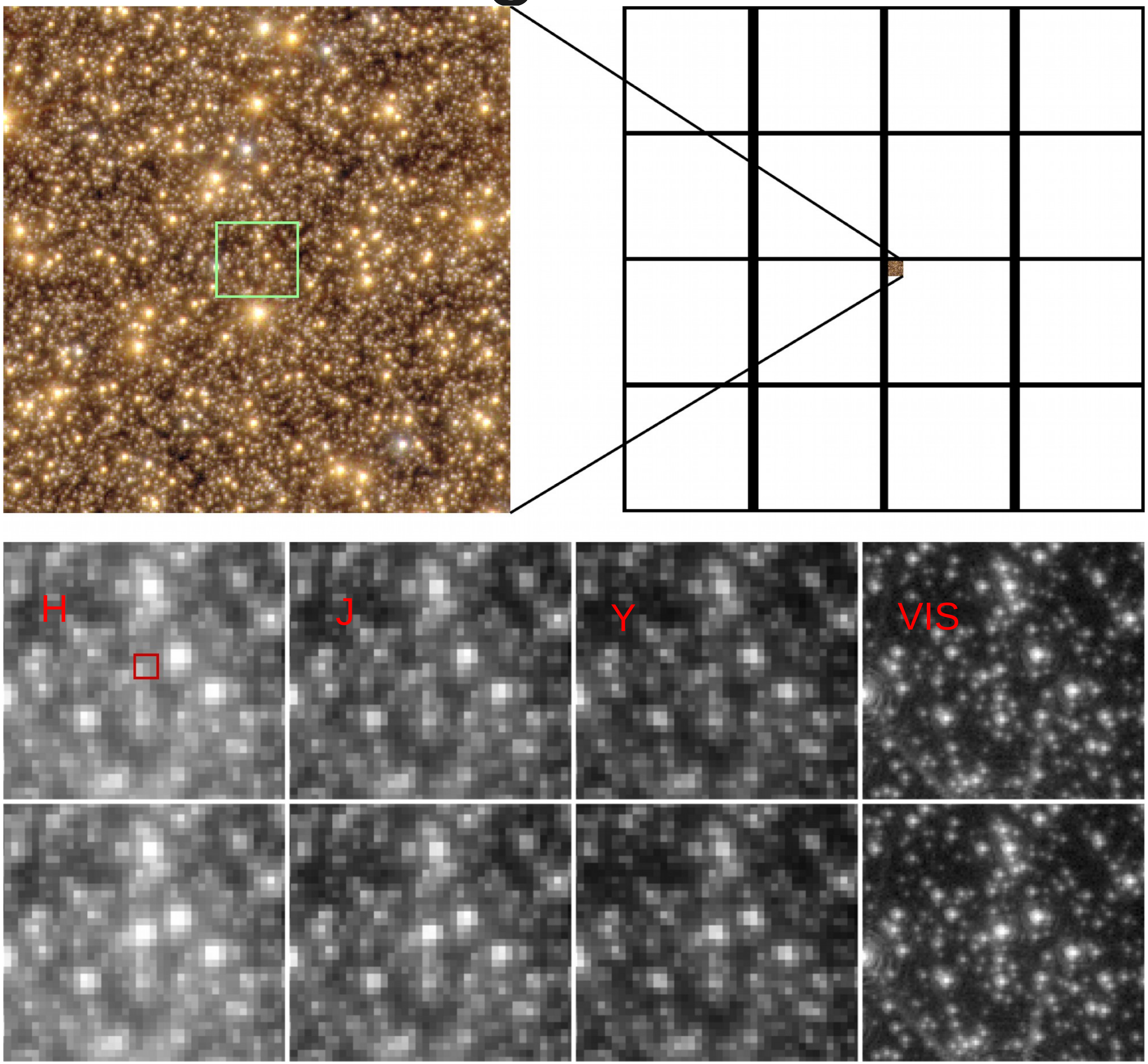


Near-IR gives a greatly enhanced microlensing signal.

Comparison with OGLE-III



Euclid “images”



MaBuLs:
Manchester-Besancon Microlensing Simulator

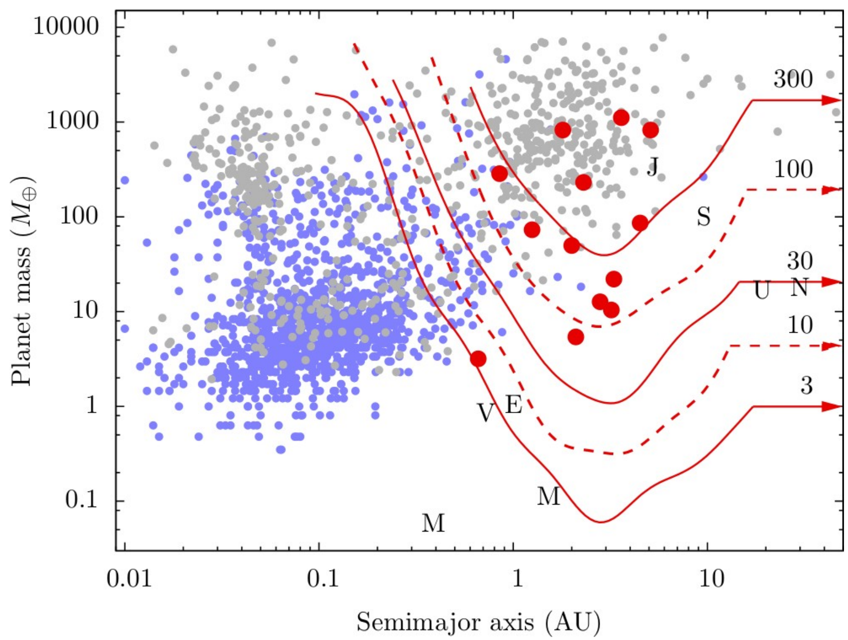
End-to-end simulations of microlensing with Euclid

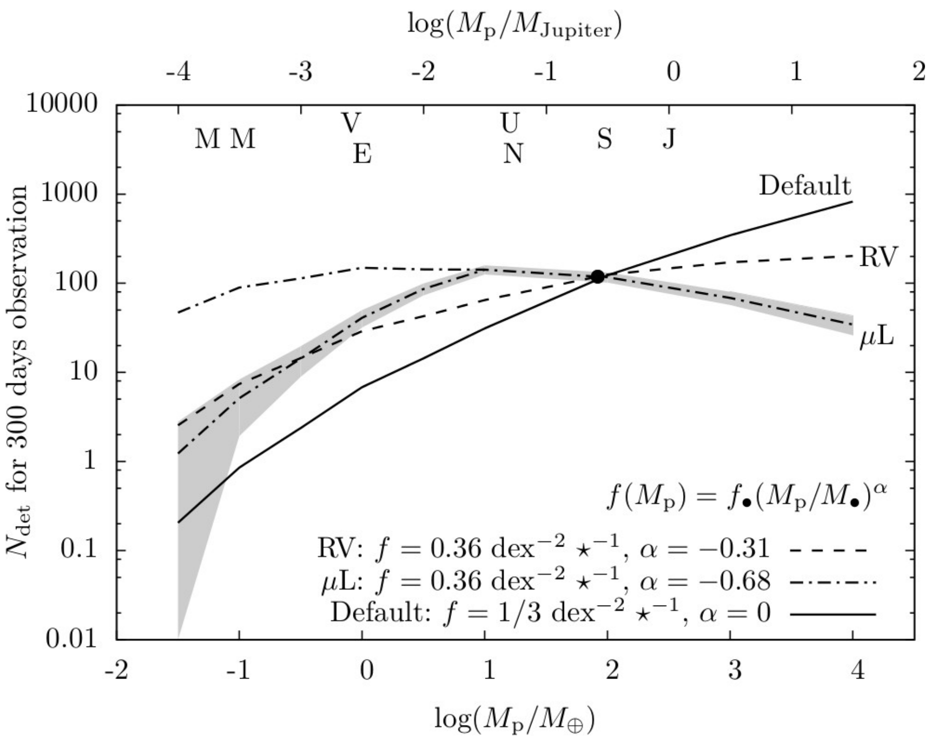
Penny, Kerins et al in prep

See tomorrow's talk by Matthew Penny

Simulation of optical + IR imagers

Current exoplanet potential of Euclid



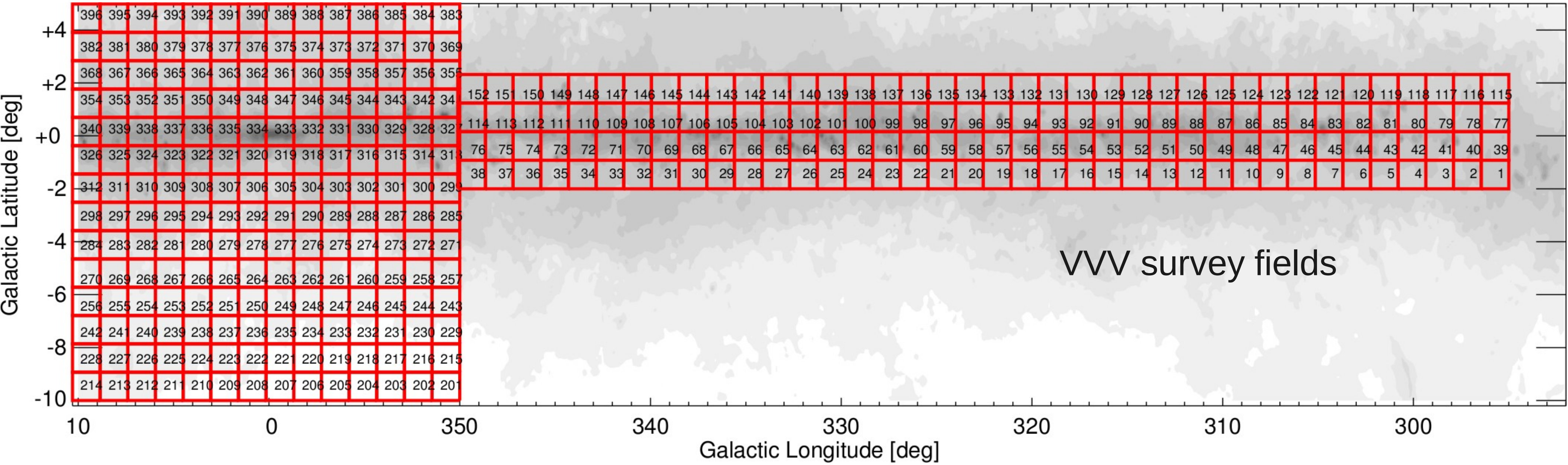


Euclid sensitivity for an assumed 10-month programme

BUT, lightcurves give us planet:host mass ratio, not planet mass directly!

Early data from Euclid will help WFIRST secure direct planet mass measurements through lens-source proper motion.

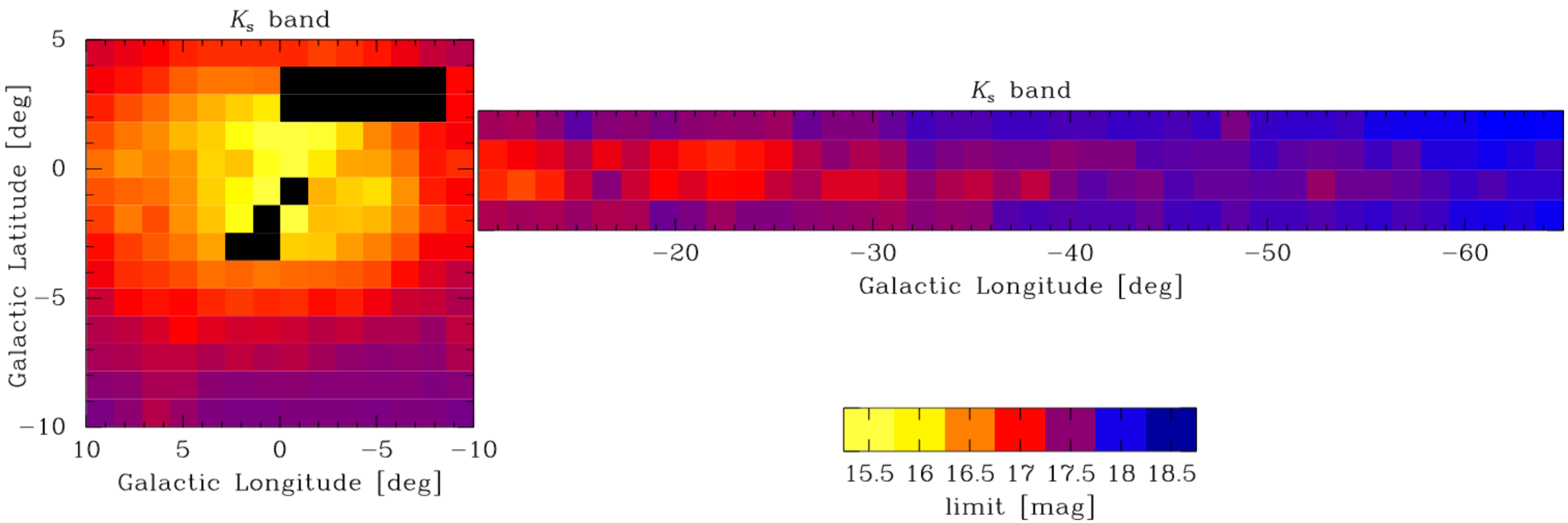
IR Microlensing in practise: VVV

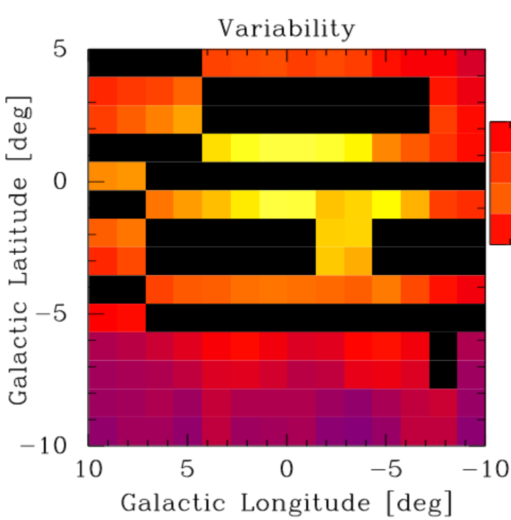


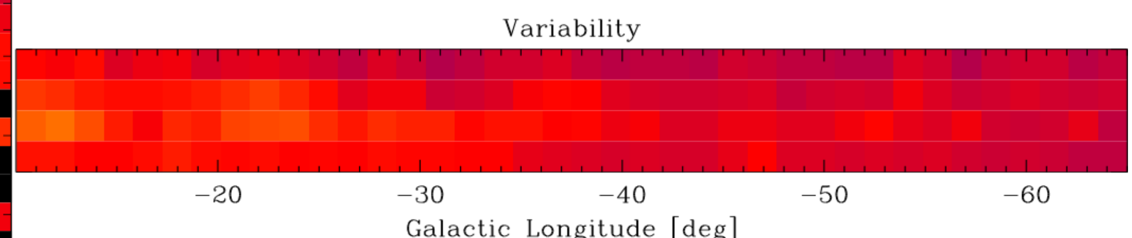
VISTA VVV survey:
5-year near IR variability survey in K-band + ZJHY colours using the 4m VISTA telescope at ESO Paranal. Coverage: 300 sq. deg over the bulge + 200 sq. deg of the disk.

VVV will provide the first empirical calibration of near-IR microlensing, helping optimisation of field placements for Euclid and WFIRST

VVV DR1: First Data Release



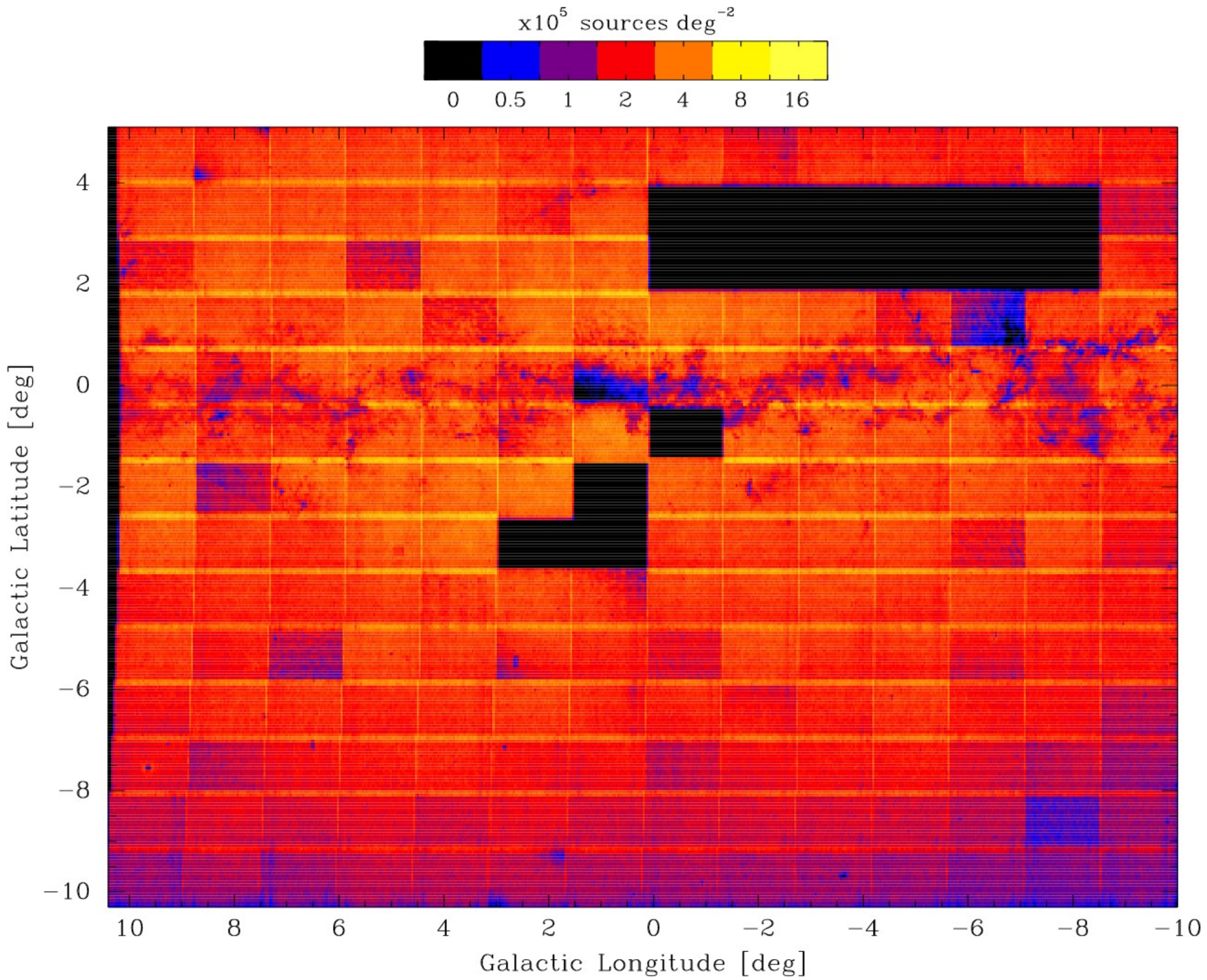




Season 3 (2012) will see a sustained 80-epoch campaign over the bulge sensitive to microlensing

DR1 sensitivity (Saito et al 2012)

VVV DR1: First Data Release



71 million point sources from DR1 (Saito et al 2012)

Euclid and WFIRST

- Baseline Euclid programme would be 3 pointings covering 1.5 sq deg with 20 min cadence in H and at least 12 hour cadence in VIS, J and Y. At least 6 months spread across the nominal mission desirable, including 1 or 2 months within the first three years of Euclid mission.
- Preference for reaction wheels to maintain depth at fixed 20 min cadence but a gas propellant survey has also been simulated.
- If, as appears likely, Euclid observations come before WFIRST then early Euclid data will facilitate WFIRST programme optimization
- Early data from Euclid will also extend the WFIRST proper motion baseline, providing more exoplanet mass measurements for WFIRST
- A Euclid + WFIRST exoplanet programme will deliver more exoplanet science than either by itself.