ULTIMATE microlensing survey

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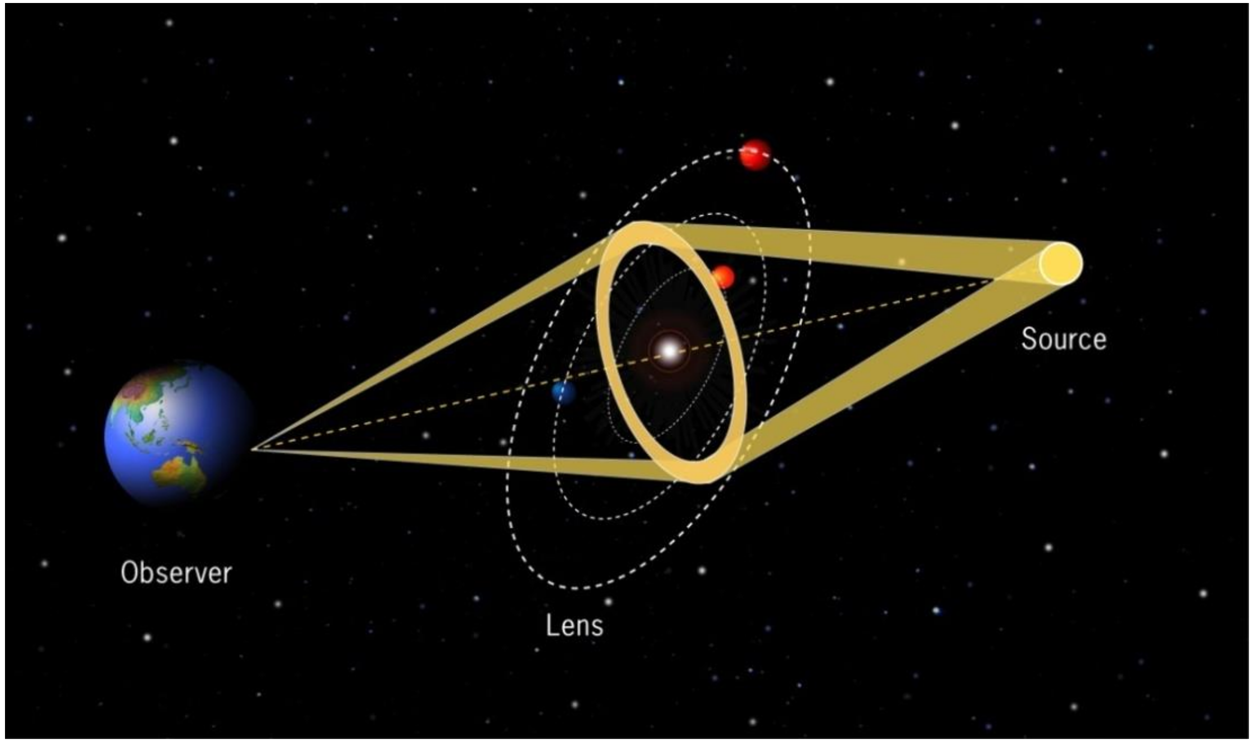
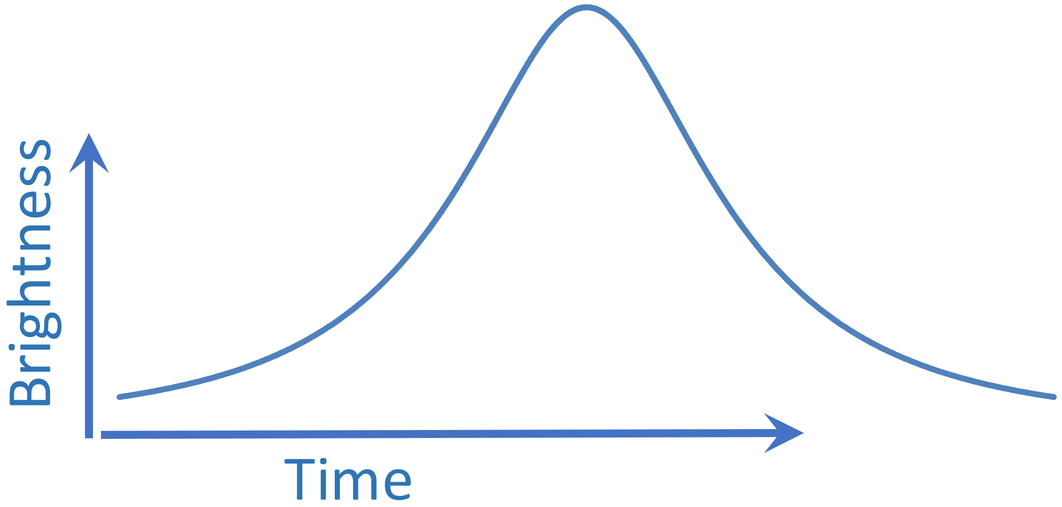
Nov 20, 2019

Planetary Microlensing



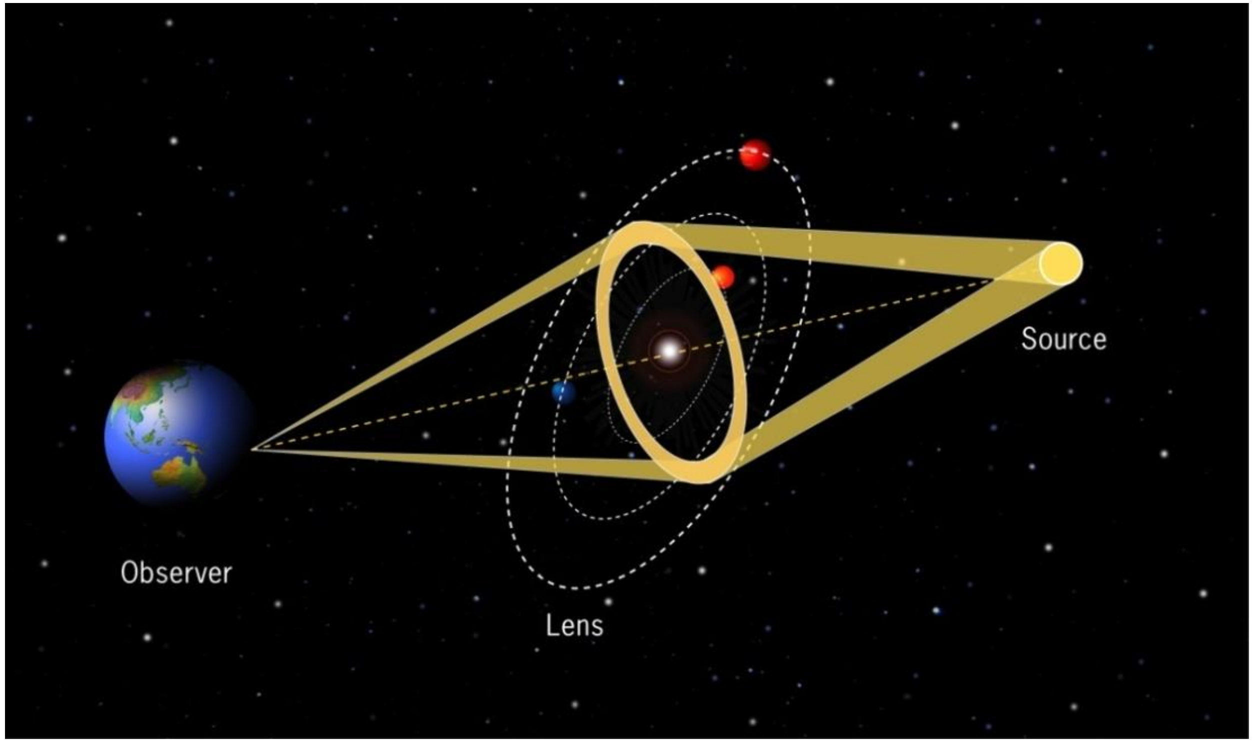


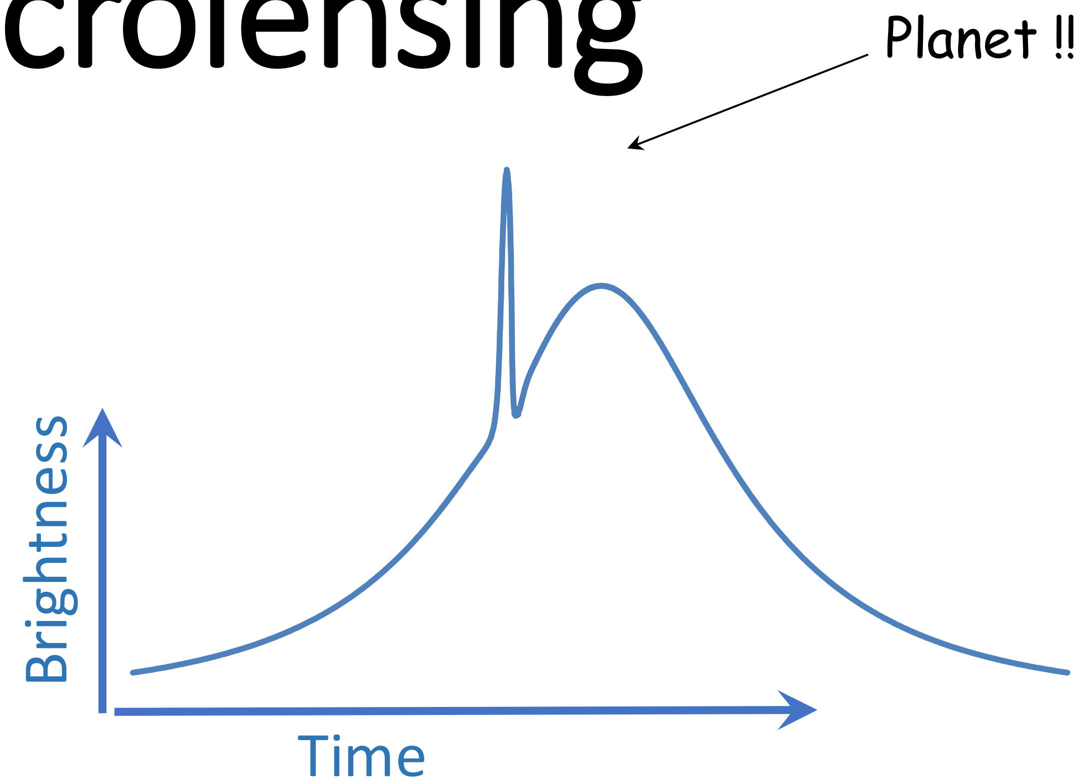
Time scale: $t_E \sim M^{1/2}$

$\sim$30 days for $0.5M_{Sun}$

Sensitive to cold planets beyond the snowline ($\sim 3a_{snow}$)

Planetary Microlensing





Sensitive to cold planets beyond the snowline (~3a_{snow})

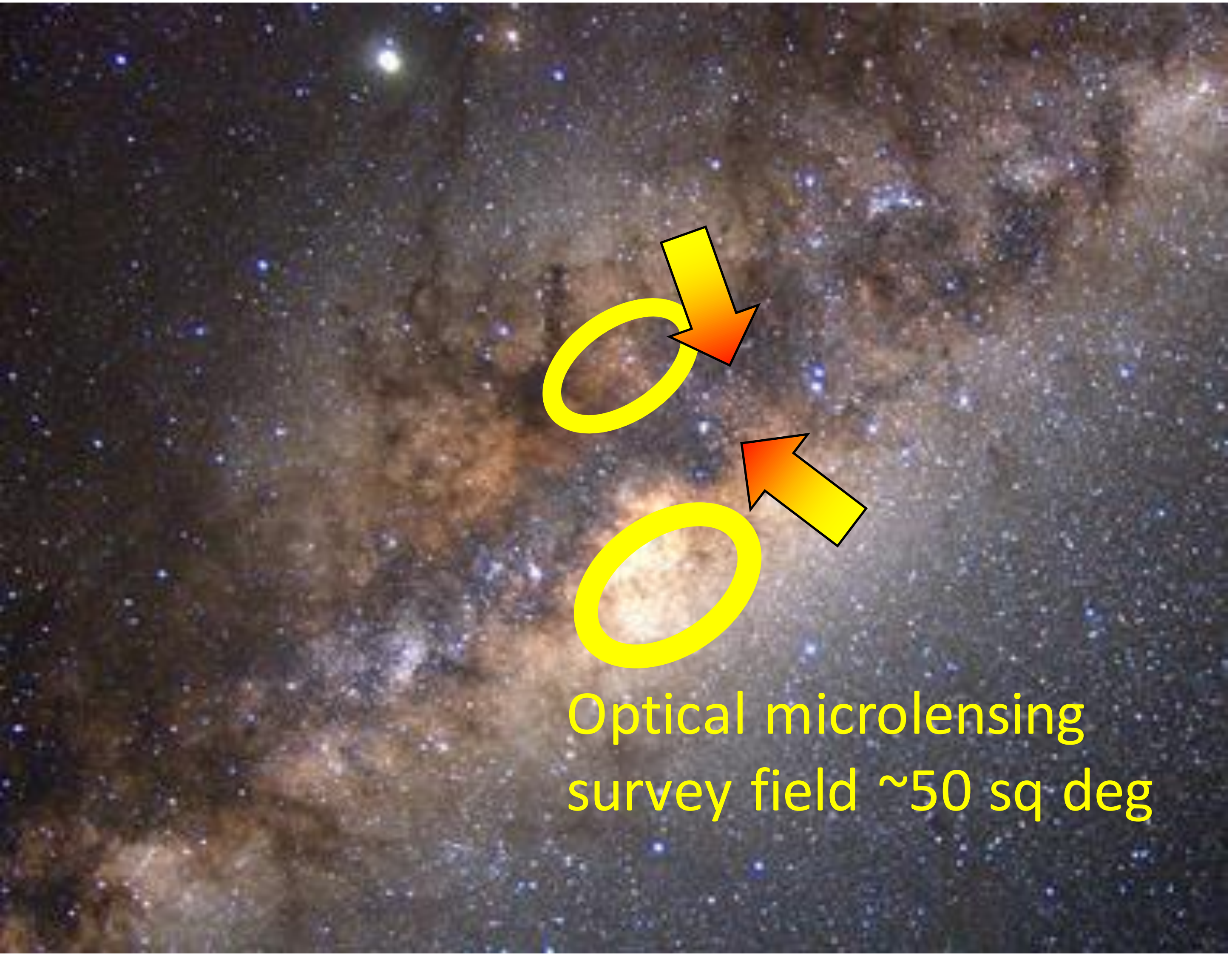
Time scale: $t_E \sim M^{1/2}$

~30 days for 0.5M_{Sun}

~a few days for $M_{Jupiter}$

~a few hours for M_{Earth}

Microlensing surveys need NIR



- The closer to the galactic center, the more stars & μlensing events

But

- Much higher dust extinction
- Much more crowded

→**NIR**
wide FOV
high-resolution

Microlensing surveys need NIR

OGLE-IV

Chile

MOA-II

NZ

KMTNet

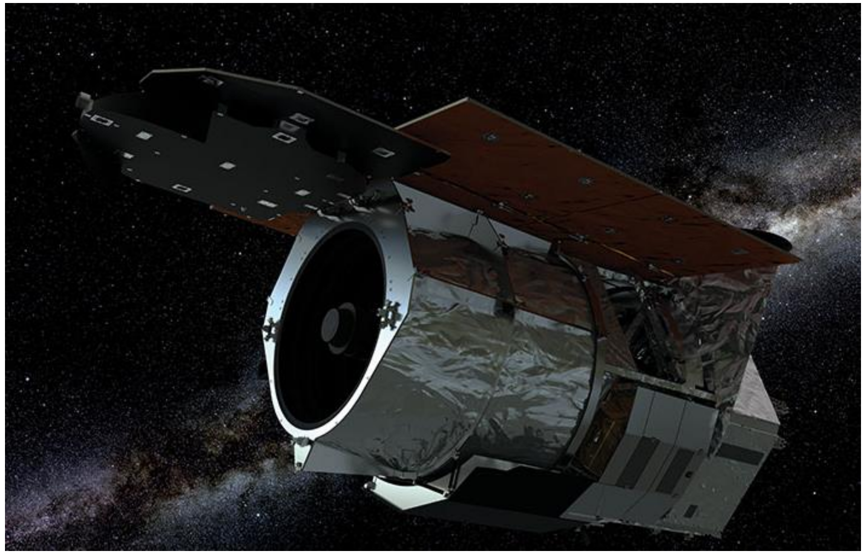
Chile, Australia, South Africa

1-2m-class telescopes
2-4 deg^2 FOV
optical filters (I-band)

PRIME (PI: T.Sumi)

1.8m telescope
1.5 deg^2 FOV
NIR filters (H-band)

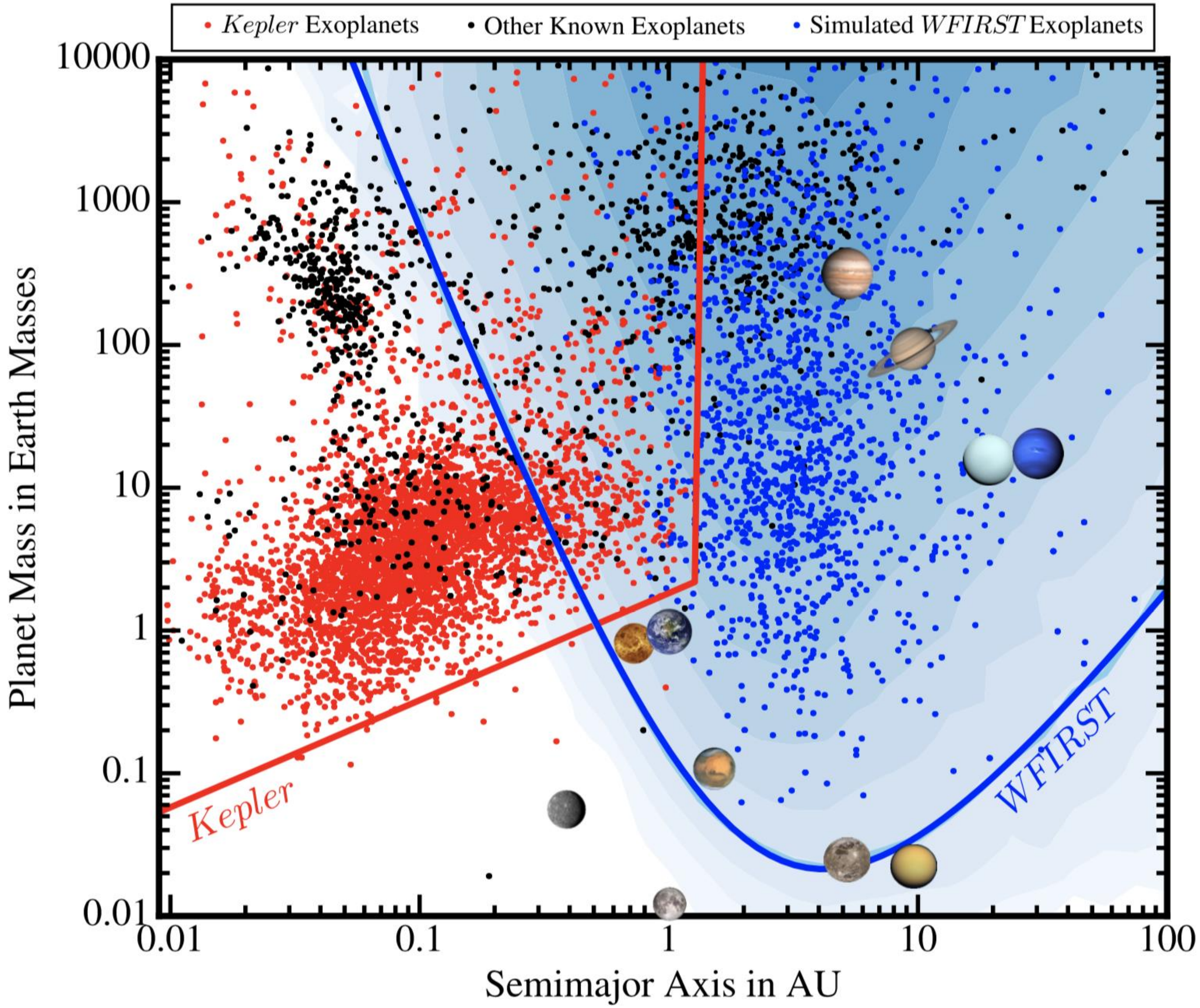
WFIRST



2.4m space telescope
0.3 deg^2 FOV
NIR filters (up to 2μm)

today → 2021~ → 2025~

Exoplanet distribution

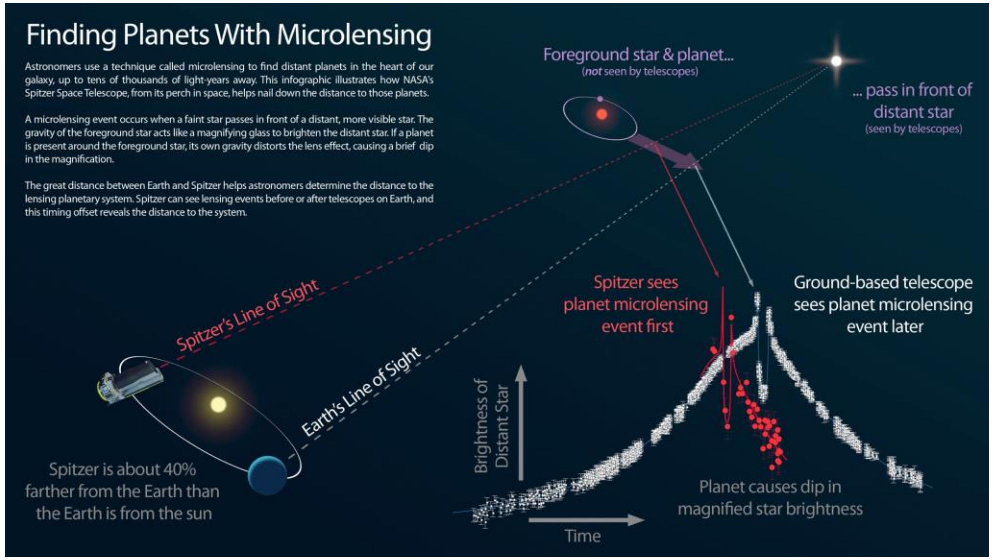


- Microlensing
- Transint
  - *Kepler*
- ■ Radial Velocity
- ▲ Direct Imaging

Penny+18

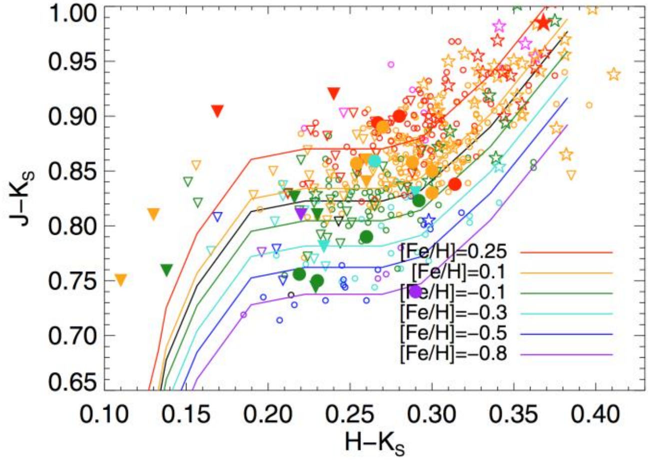
WFIRST – ULTIMATE-Subaru Concurrent Obs:

1. **To measure the microlensing parallax for mass & distance measurement**
   - ✓ K-band can penetrate highly extincted region, where event rate is higher.
   - ✓ Complement to HSC/LSST/PRIME
2. **To characterize the host (lens) star**
   - ✓ Complement to WFIRST filters (<2μm)
   - ✓ (Z087-K) and (W146-K) colors
   - ✓ → Metallicity of M-dwarf hosts
3. **To detect long time-scale (BH) event**
   - ✓ light-curve, parallax + resolved images
   - ✓ Mass measurement of isolated BHs



Udalski+15

NIR color-color diagram of nearby M-dwarfs



Newton+14

Acknowledgements to D.Bennett

K-band Microlensing Survey toward the Galactic Center

THE ASTROPHYSICAL JOURNAL, 446:L71–L73, 1995 June 20

K-BAND MICROLENSING OF THE INNER GALAXY

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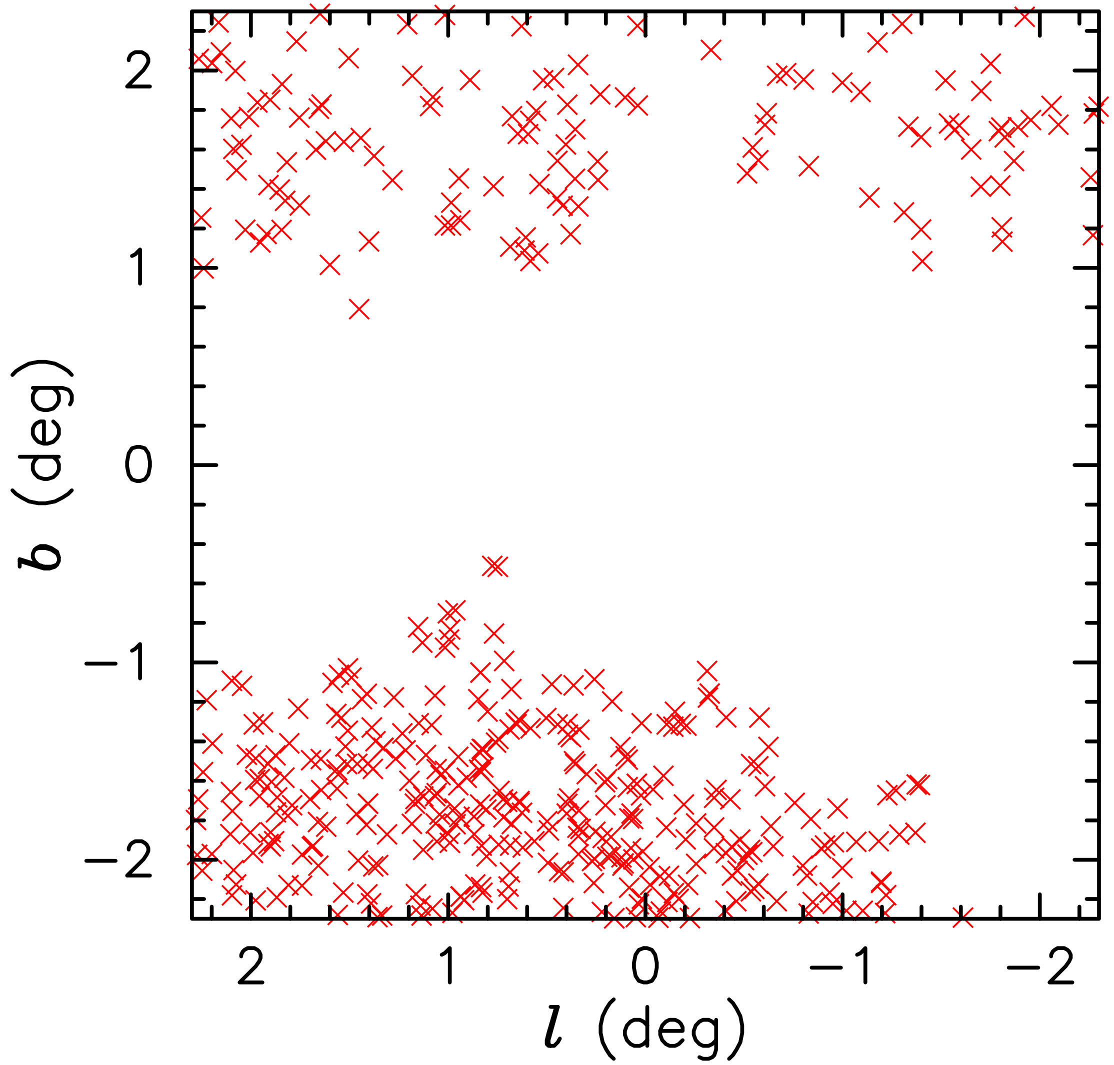
ABSTRACT

Microlensing searches toward the inner galaxy ($|l|, |b| \leq 22'.5$) have several major advantages. First, the event rate is strongly dominated by bulge-bulge lensing events where both the source and lens lie in the bulge. Second, these bulge-bulge events have very short timescales $t_e \sim 2$ days and are therefore easily distinguished from the less frequent and much longer bulge-disk and disk-disk events. Third, since the optical depth is similar to that at higher impact parameters, while the events are shorter, the event rate is high, $\Gamma \sim 3 \times 10^{-7}$ day^{-1}. Fourth, because the Einstein rings are small, $r_e \sim 5 \times 10^{12}$ cm, and the source stars are large, $r_s \gtrsim 10^{12}$ cm, the lens will transit the face of the source for a significant fraction (~20%) of events. For these transit events it will often be possible to measure a second lens parameter, the angular Einstein radius (or proper motion). In addition to the bulge-bulge events, the optical depth of the disk is ~3 times larger toward the

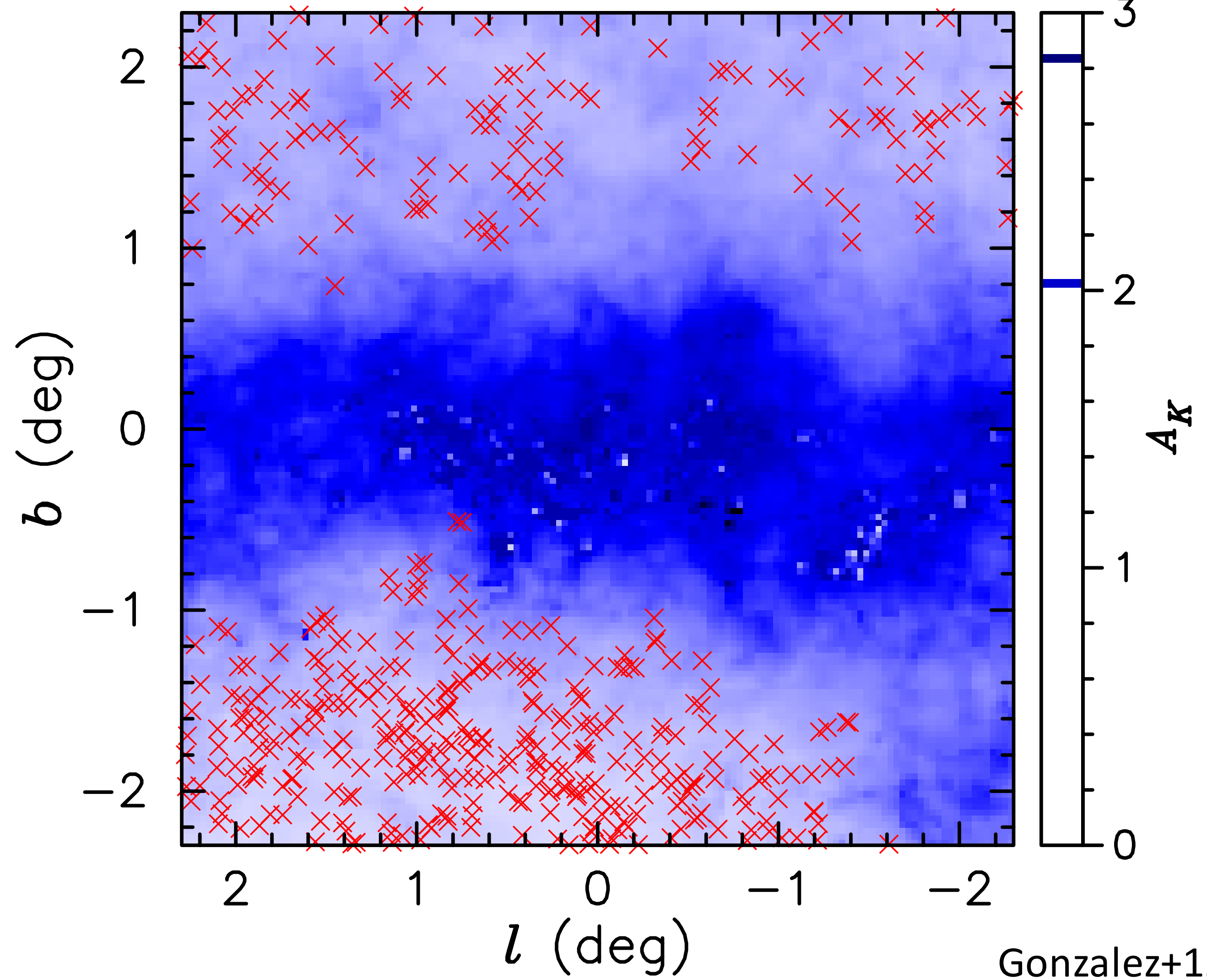
K-band Microlensing Survey toward the Galactic Center



Microlensing events (OGLE)

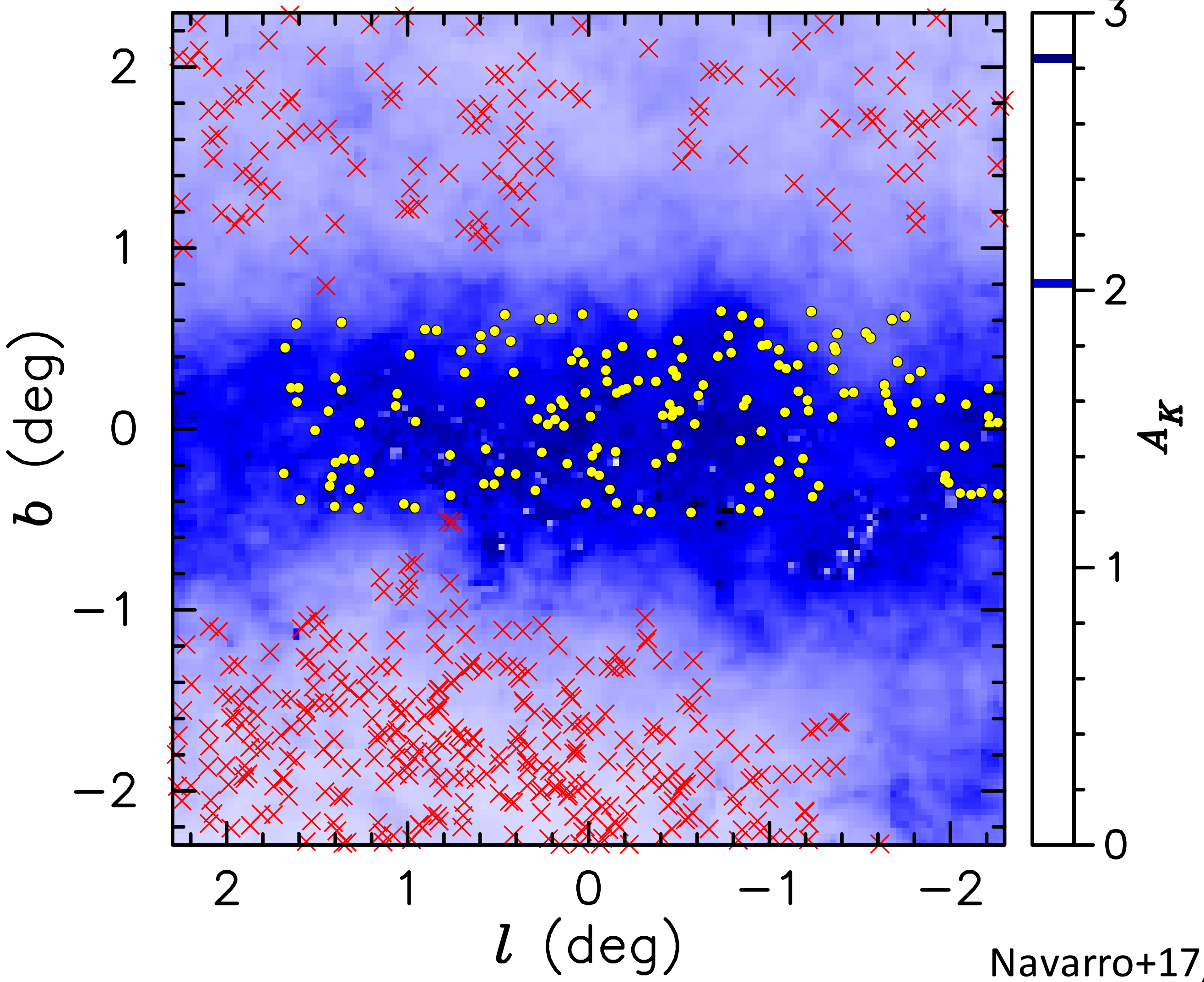
http://ogle.astrouw.edu.pl/ogle4/ews/ews.html

K-band Microlensing Survey toward the Galactic Center



Gonzalez+12

K-band Microlensing Survey toward the Galactic Center

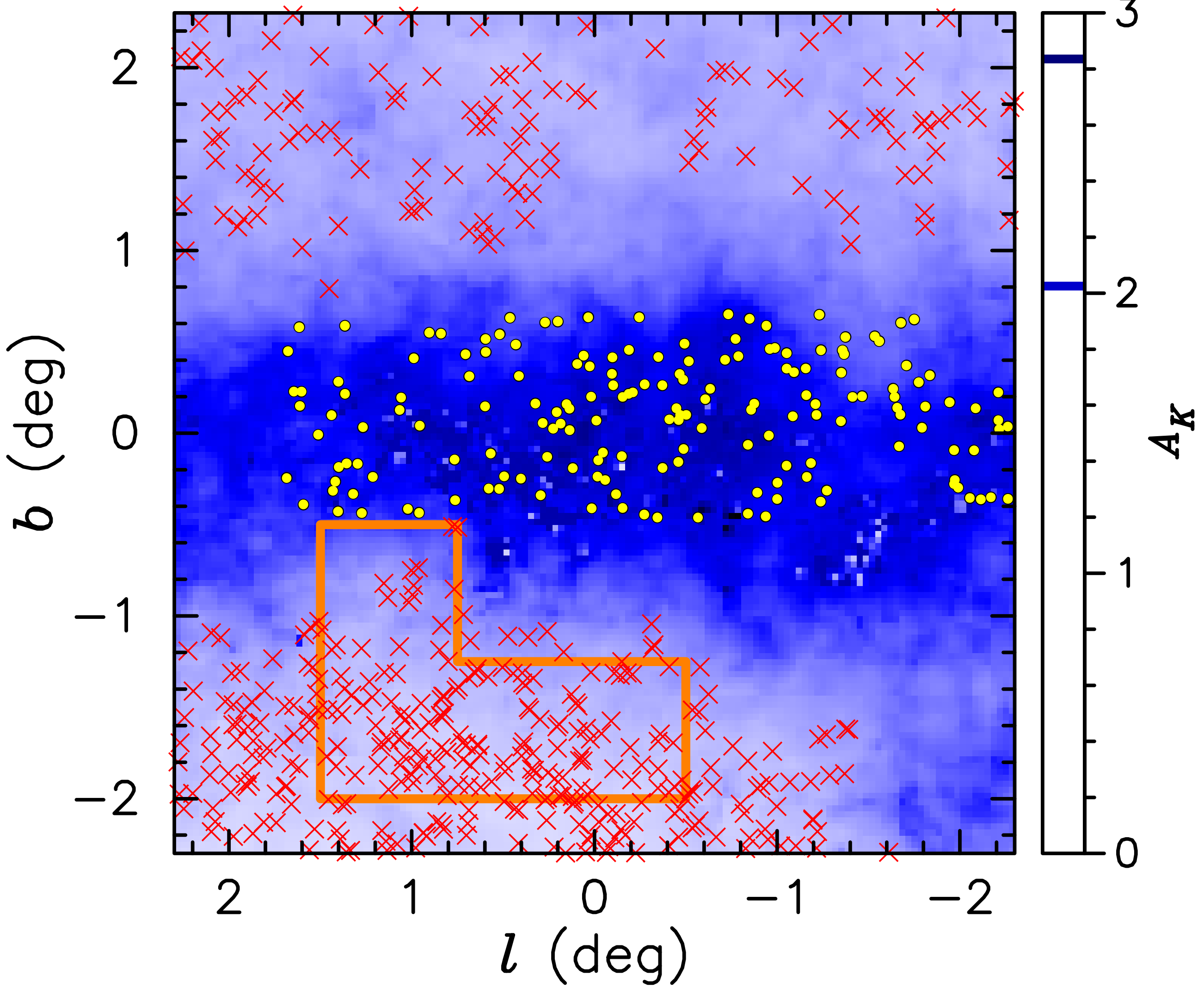


Microlensing events (OGLE)

Microlensing events (VVV)

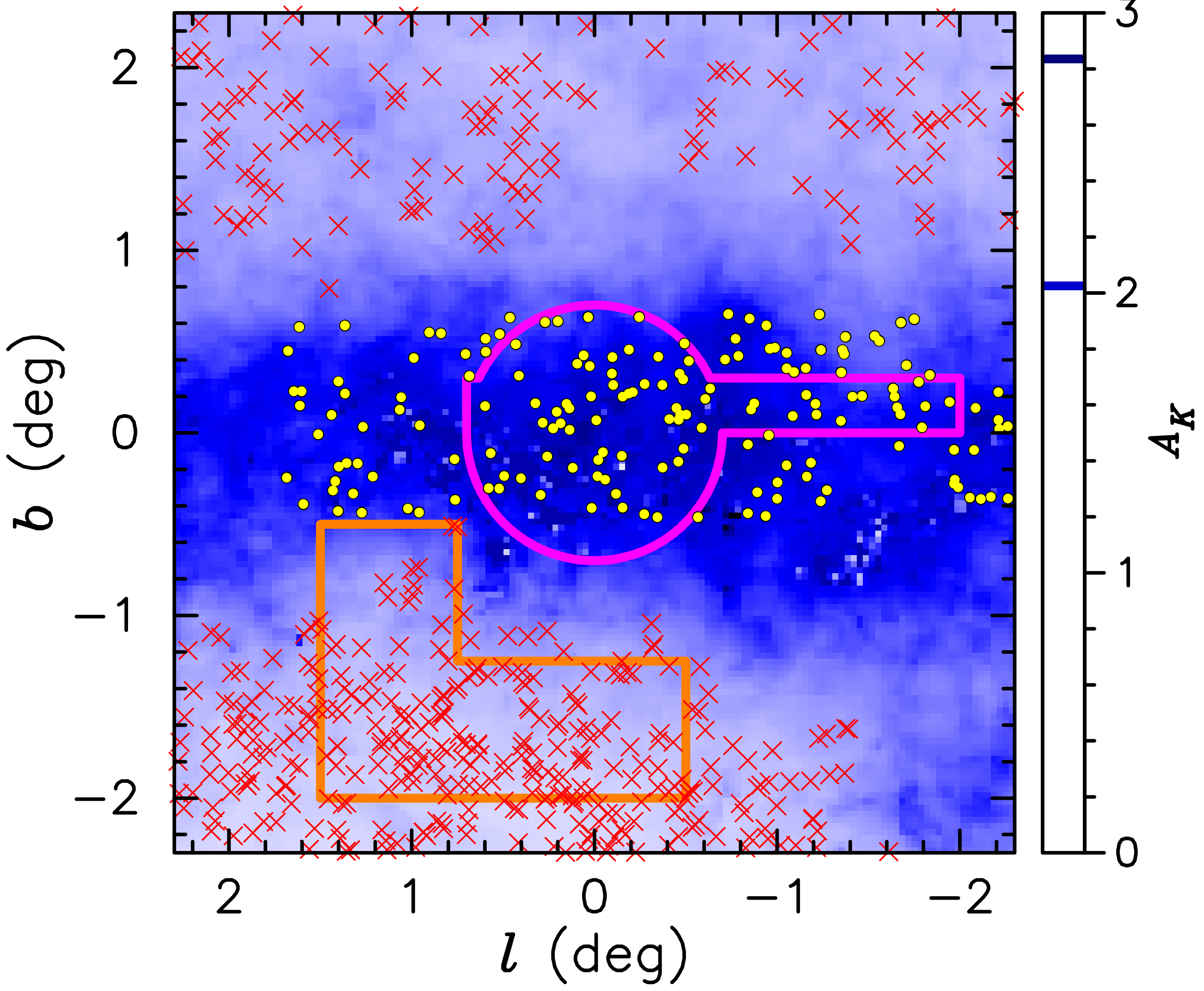
Navarro+17, 18

K-band Microlensing Survey toward the Galactic Center



Microlensing events (OGLE)
Microlensing events (VVV)
WFIRST μ-lens survey field (2025~)

K-band Microlensing Survey toward the Galactic Center



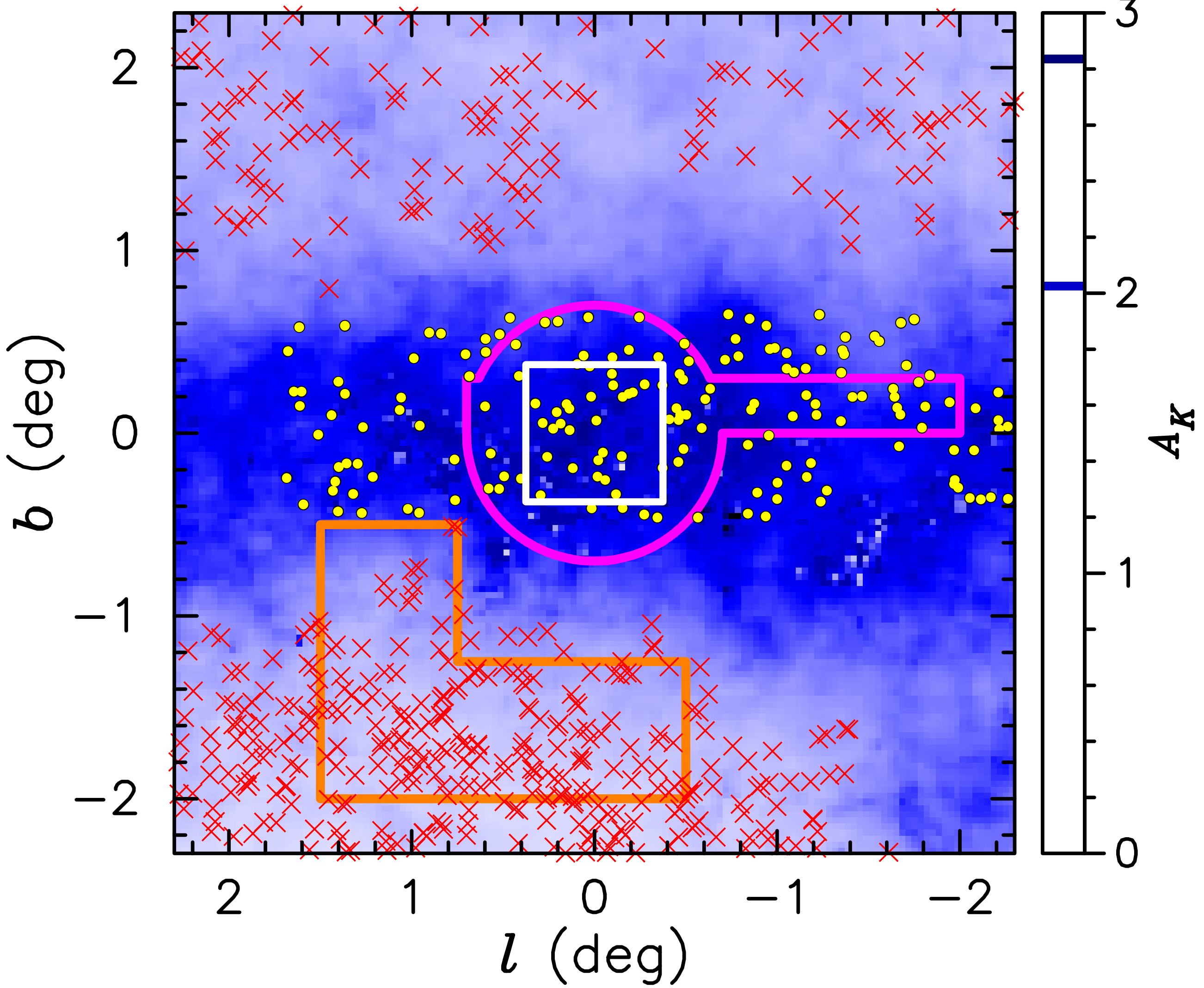
Microlensing events (OGLE)

Microlensing events (VVV)

WFIRST μ-lens survey field (2025~)

JASMINE field (2024~)

K-band Microlensing Survey toward the Galactic Center



Microlensing events (OGLE)

Microlensing events (VVV)

WFIRST μ-lens survey field (2025~)

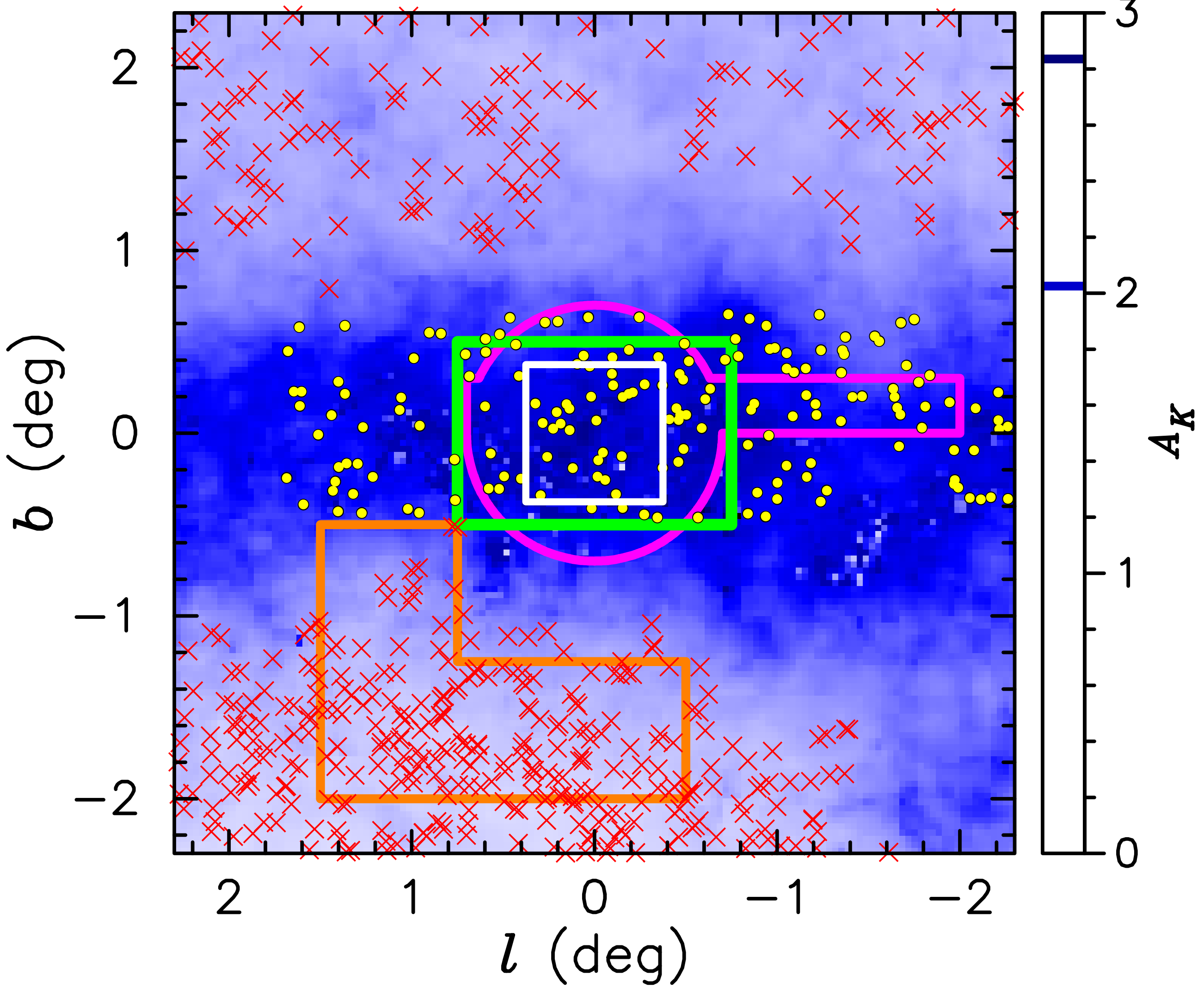
JASMINE field (2024~)

Gould 95 suggestion

K-band μlensing Survey w/ ULTIMATE-Subaru

- **To understand the inner Galactic bulge structure**
  - 1/hour cadence will be enough to detect microlensing events (~2days time scale)
- **To understand the planet formation at the inner Galactic bulge**
  - High cadence (every 15-20min) photometry would be needed.
  - Strong finite source effect might wash out the planetary signals for the giant source stars.
  - →K-band, wide FOV, high spatial resolution, deep imaging: **only ULTIMATE-Subaru can achieve**

K-band Microlensing Survey toward the Galactic Center



Microlensing events (OGLE)
Microlensing events (VVV)
WFIRST μ-lens survey field (2025~)
JASMINE field (2024~)
Gould 95 suggestion
ULTIMATE Subaru (late 2020s)

Summary

ULITMATE-Subaru can be used for the ultimate μlensing surveys

1. **WFIRST – ULTIMATE-Subaru concurrent observation**
    - To measure the microlensing parallax toward the highly obscured region for **planet mass and distance measurement**
    - To characterize the lens star by the color measurement for the **host star metallicity**
    - To measure long events for **mass measurement of BHs**
2. **K-band microlensing survey toward the inner Galactic bulge**
    - To understand the **inner Galactic bulge structure**
    - To study the **planet formation at the inner Galactic bulge**