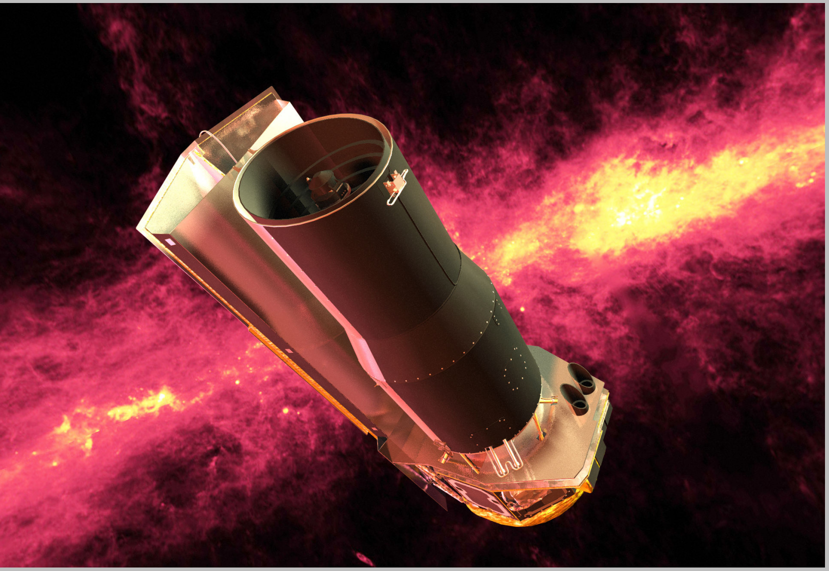
Space-based Microlensing with *Spitzer* and K2

Calen B. Henderson

The Ohio State University

WFIRS 2014

Tuesday, 18/Nov/2014



NASA/JPL-Caltech via Wikipedia

NASA/JPL-Caltech/Wendy Stenzel via Wikipedia

Converting Observables to Physical Properties

From ground alone, measuring two-body mass ratio *q* is routine:

$$q = \frac{M_p}{M_*}$$

Converting Observables to Physical Properties

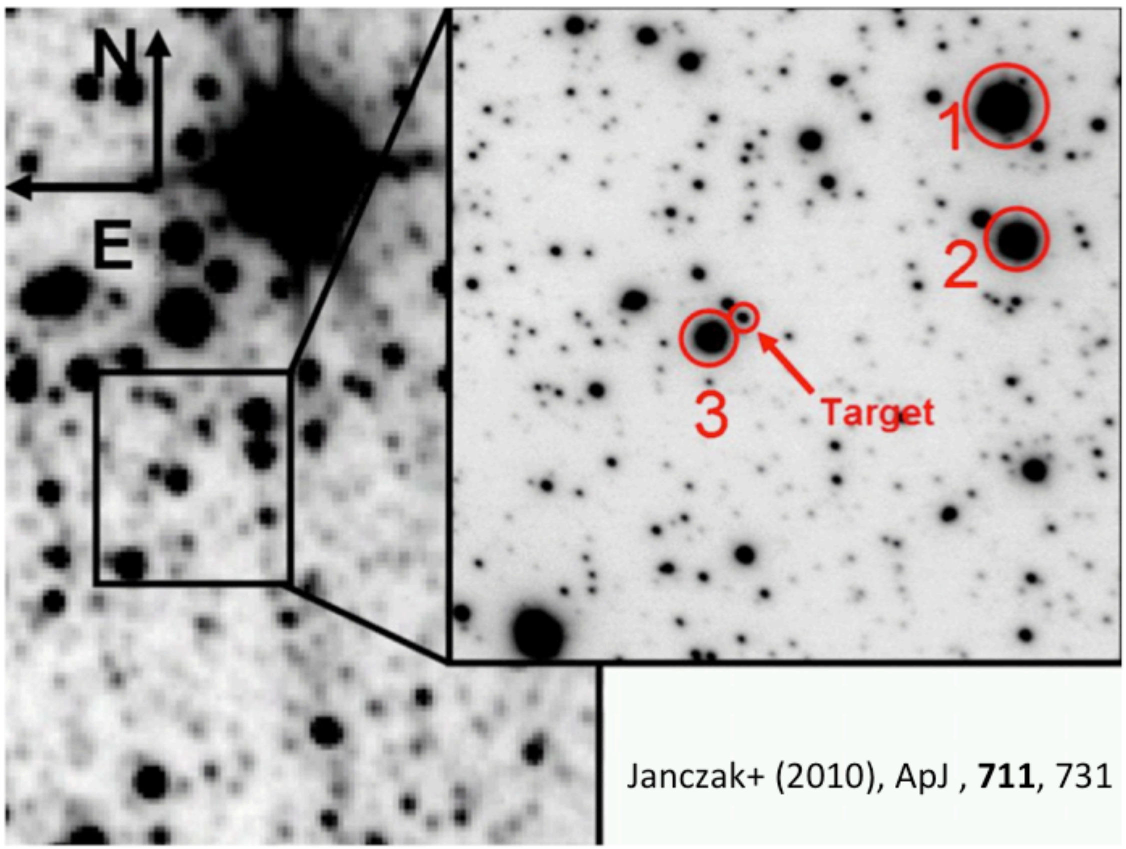
From ground alone, measuring two-body mass ratio *q* is routine:

$$q = \frac{M_p}{M_*}$$

→ **But how to determine M_p and M_*?**
Or M_l for individual lens masses?

Converting Observables to Physical Properties

1) High-resolution Photometric Follow-up



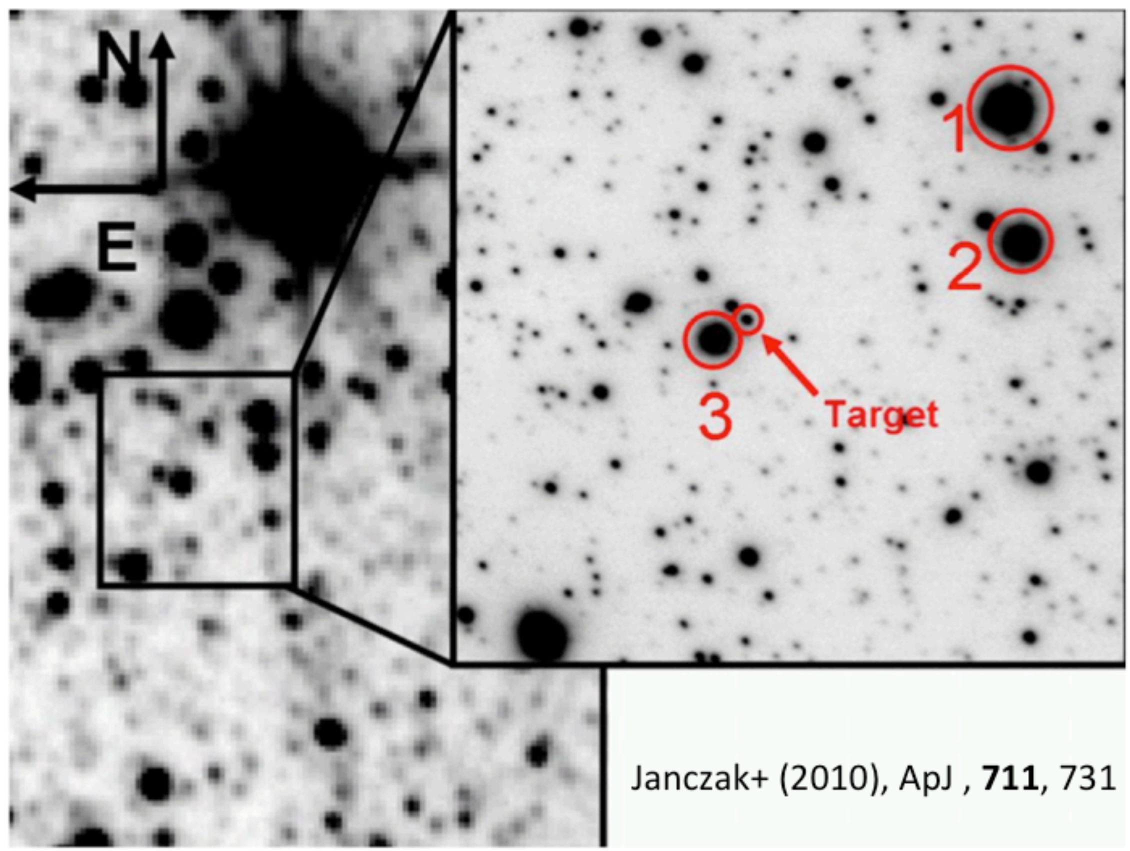
Janczak+ (2010), ApJ , **711**, 731

Converting Observables to Physical Properties

1) High-resolution Photometric Follow-up

$F_{lens} = F_{target} - F_{source}$

$F_{lens} \rightarrow M_{lens}$



Janczak+ (2010), ApJ , **711**, 731

Converting Observables to Physical Properties

2) Microlens Parallax π_E

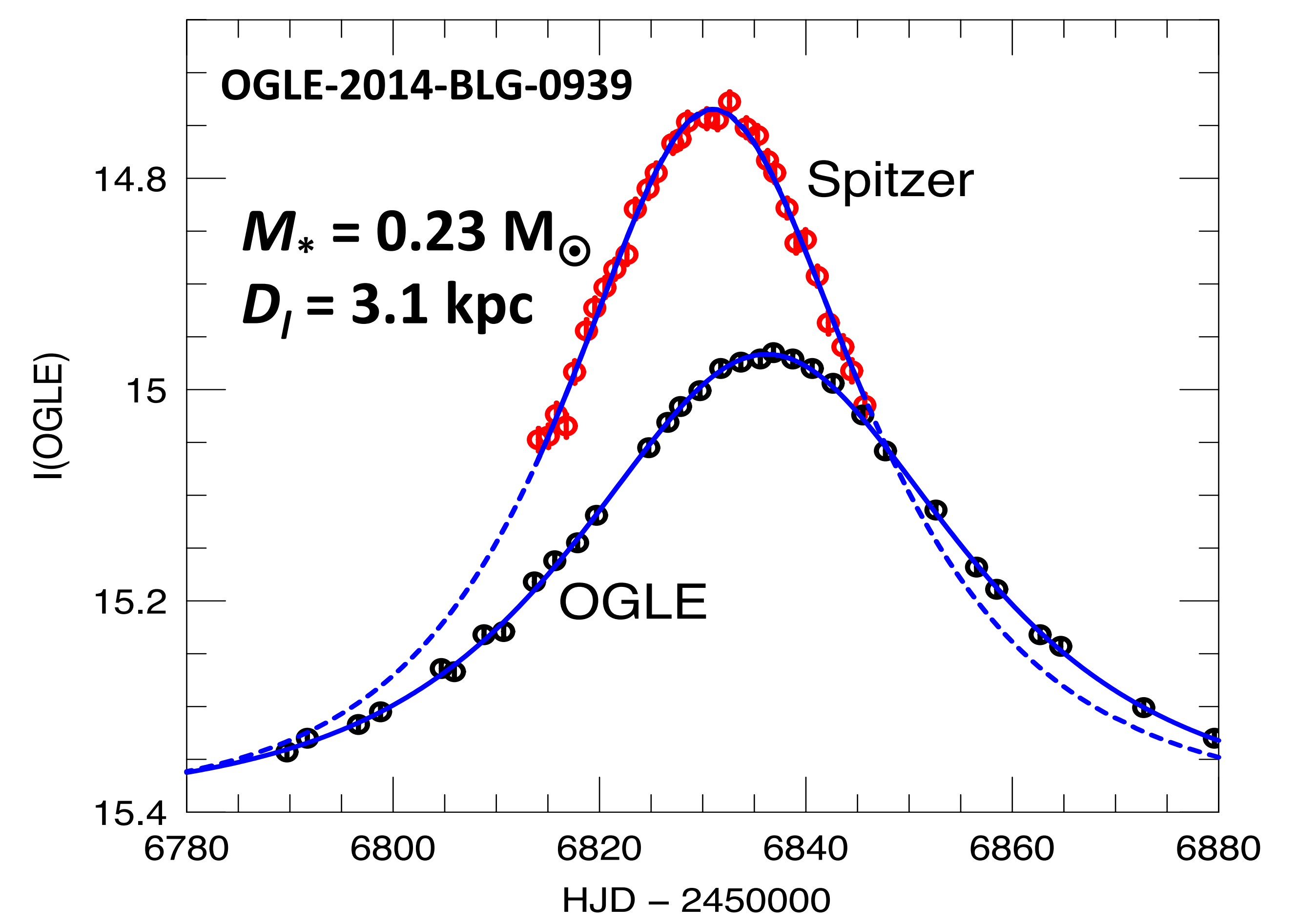
$$M_{tot} \propto \frac{\theta_E}{\pi_E}$$

θ_E (Einstein radius): Color measurements of source star + finite-source effects

π_E via satellite parallax: Simultaneous observations from ground and space

Spitzer Results I: Mass Measurement of an Isolated Star

Re: Talk Monday by Sebastiano Calchi Novati

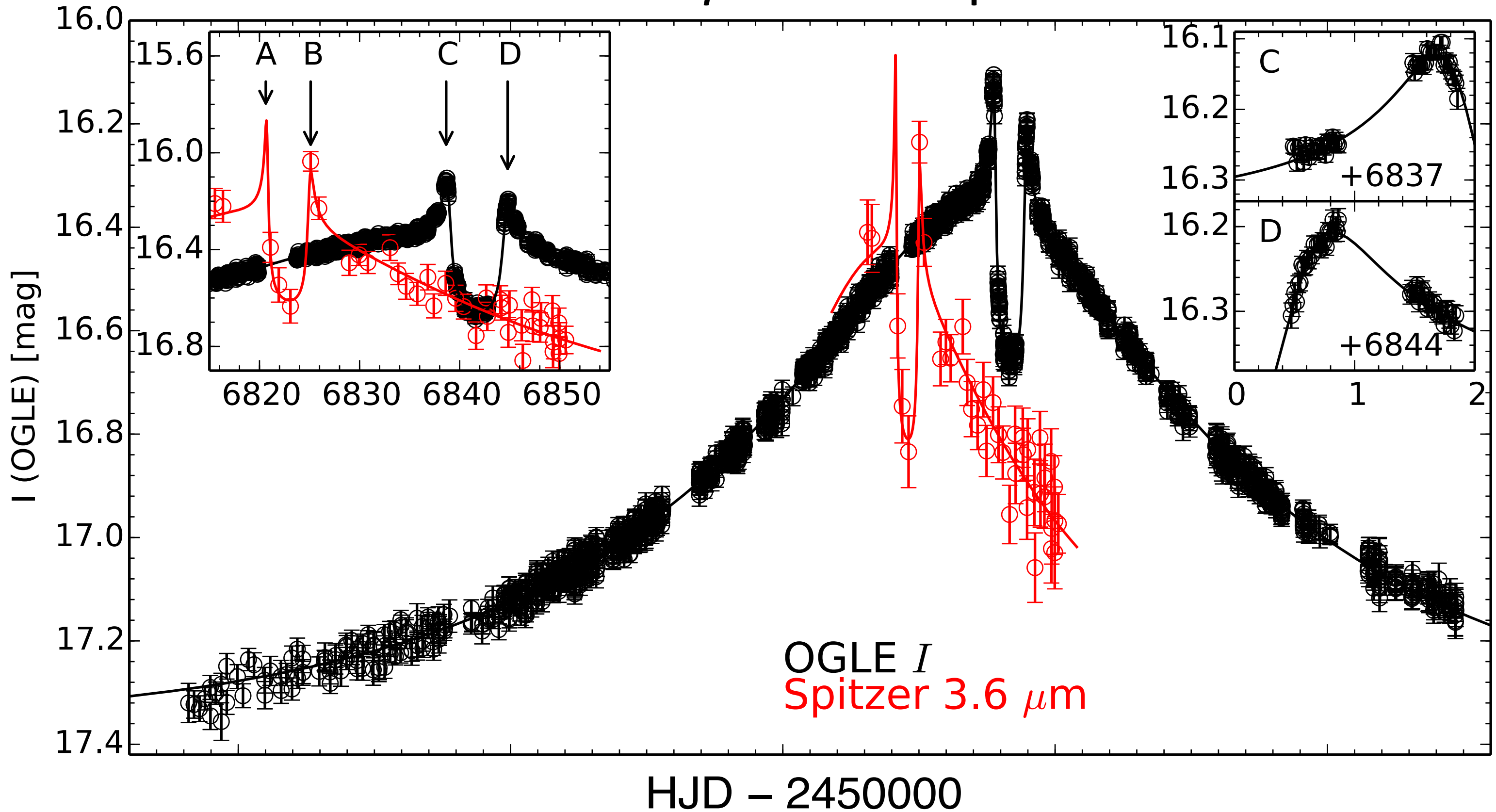


J. C. Yee+ (2014), arXiv: 1410.5429

Spitzer Results II: Space-based Exoplanet Microlens Parallax

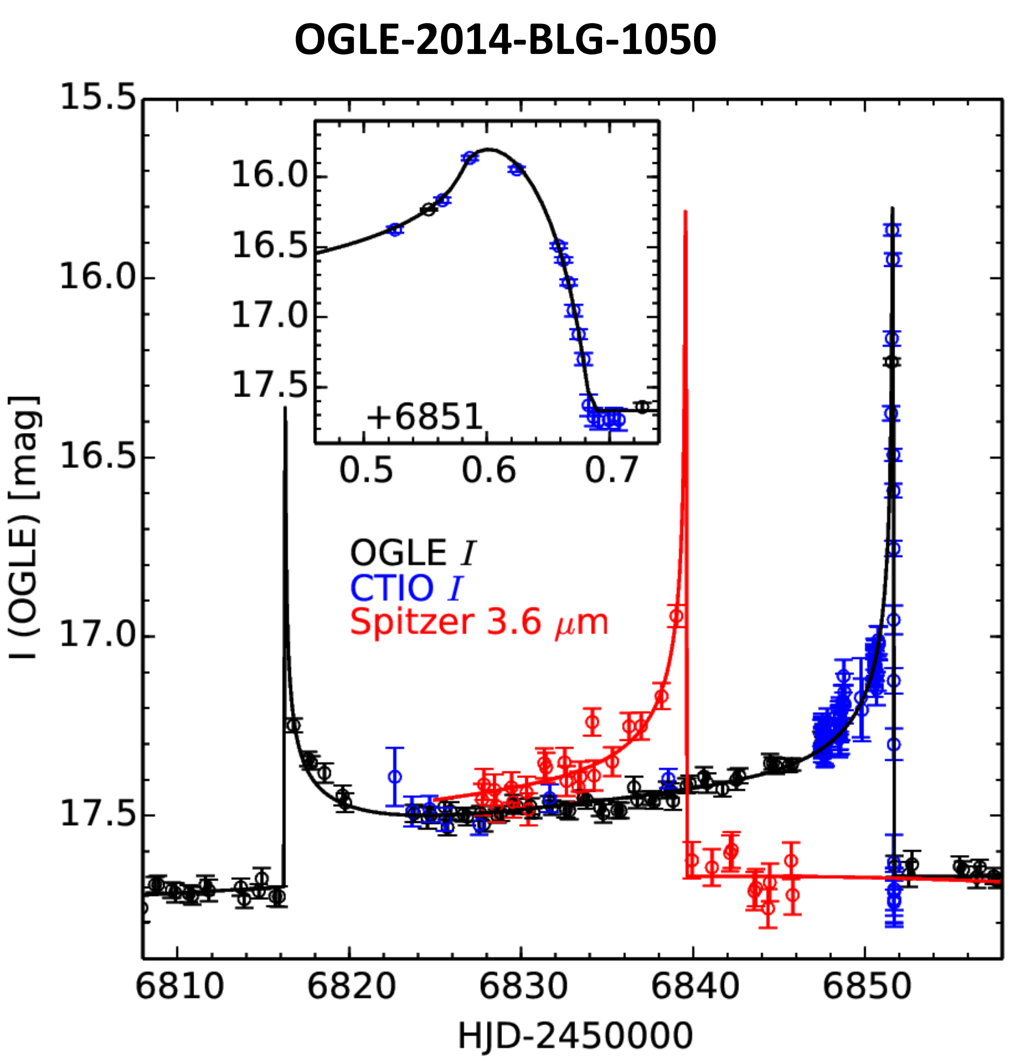
Re: Talk Monday by Sebastiano Calchi Novati

OGLE-2014-BLG-0124 $M_p = 0.5\ M_{Jup}$ $M_* = 0.7\ M_\odot$



A. Udalski+ (2014), arXiv: 1410.4219

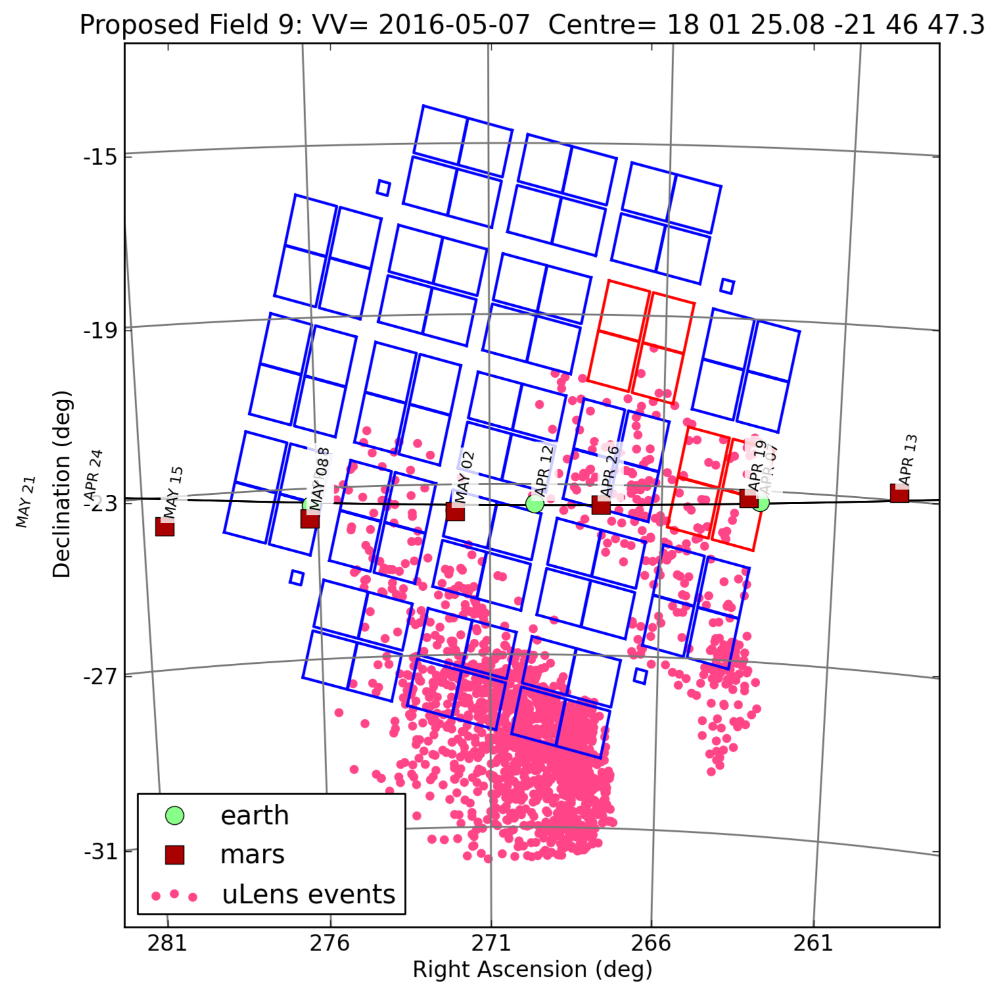
Spitzer Results III: Masses of Binary Star Components



See poster by Wei Zhu!

K2 Campaign 9:
75-day Survey of Galactic Bulge

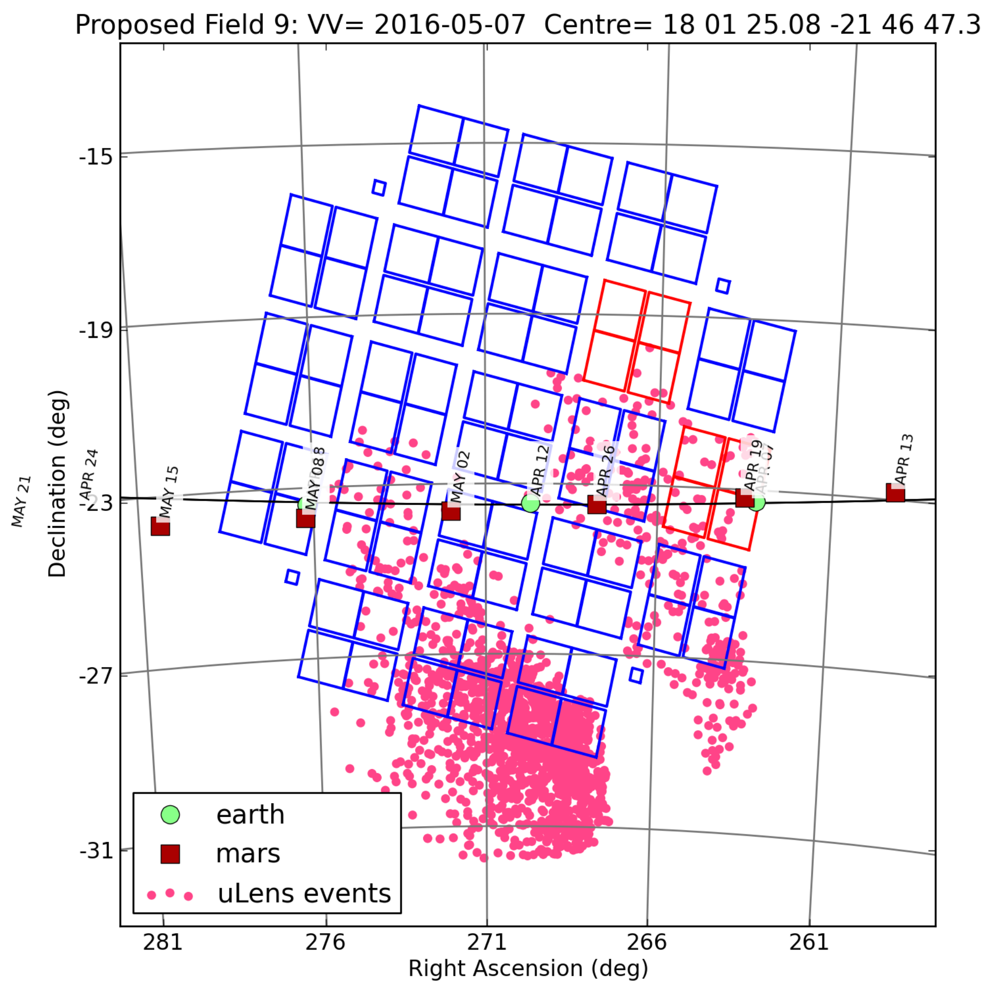
- 6/April – 29/June, 2016
- Long-cadence (30min) exposures
- Total FoV ~ 7 sq. deg.
- No ~real-time trigger; automated survey



K2 Campaign 9:
75-day Survey of Galactic Bulge

- 6/April – 29/June, 2016
- Long-cadence (30min) exposures
- Total FoV ~ 7 sq. deg.
- No ~real-time trigger; automated survey

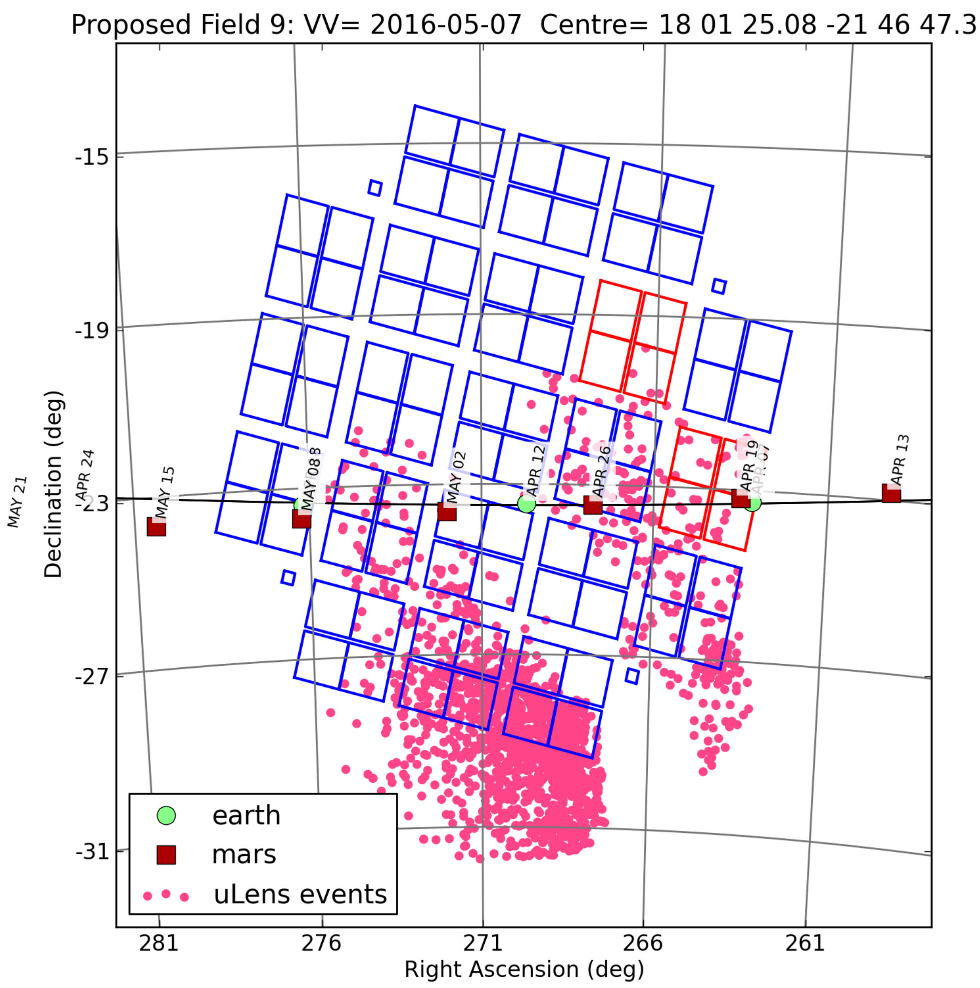
→ **Masses of free-floating planets (FFPs)!**



K2 Campaign 9:
FFP Masses via Joint Ground-based Effort

WANT:

- Similar FoV
- Cadence: FFP μlensing events are short
- Depth: Maximize photometric overlap

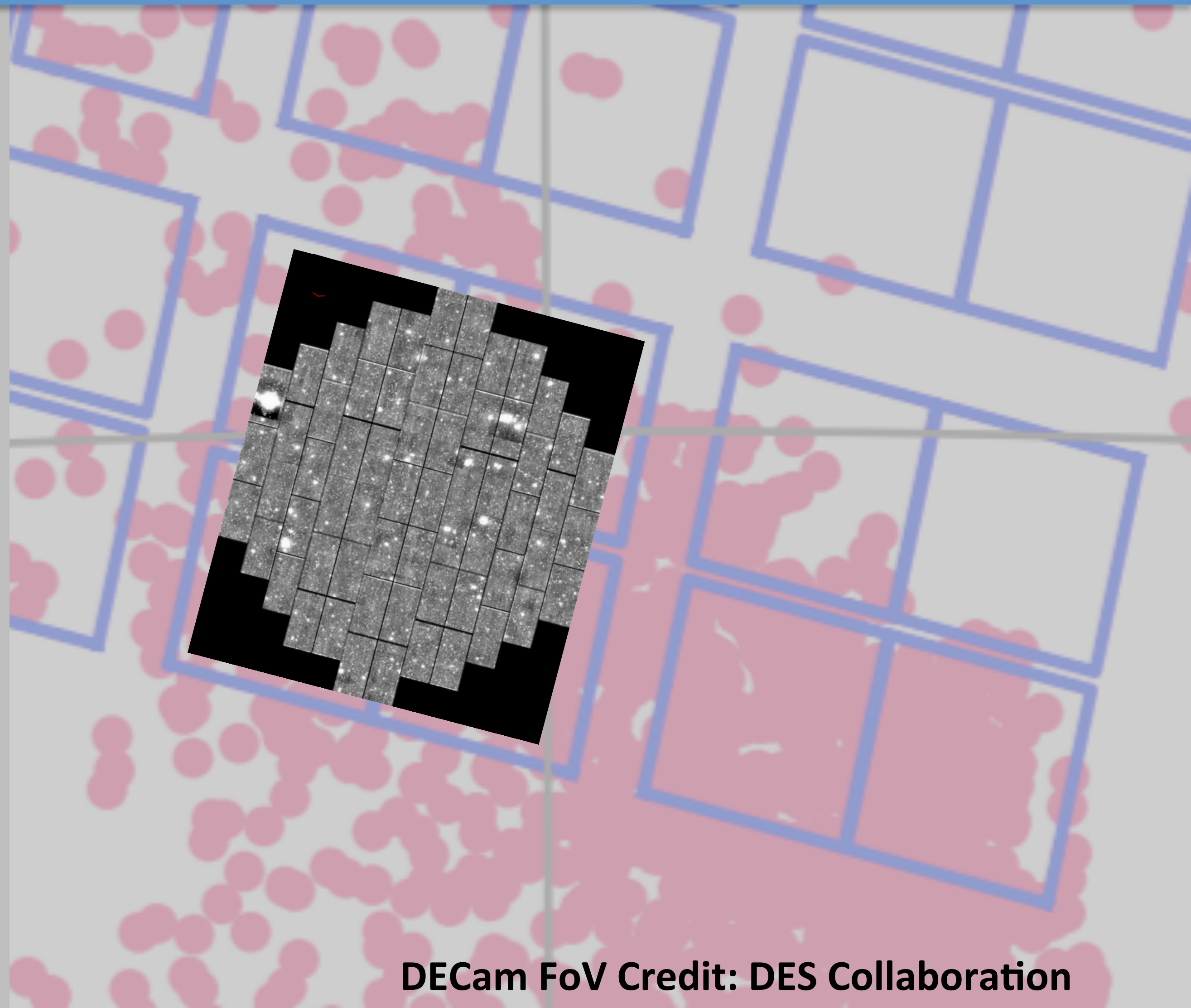


Free-floating Planet Masses
K2 + DECam

DECam Survey

- FoV ~ 3 sq. deg.
- Two fields
- g: ~15m
- r: 20s
- z: 20s

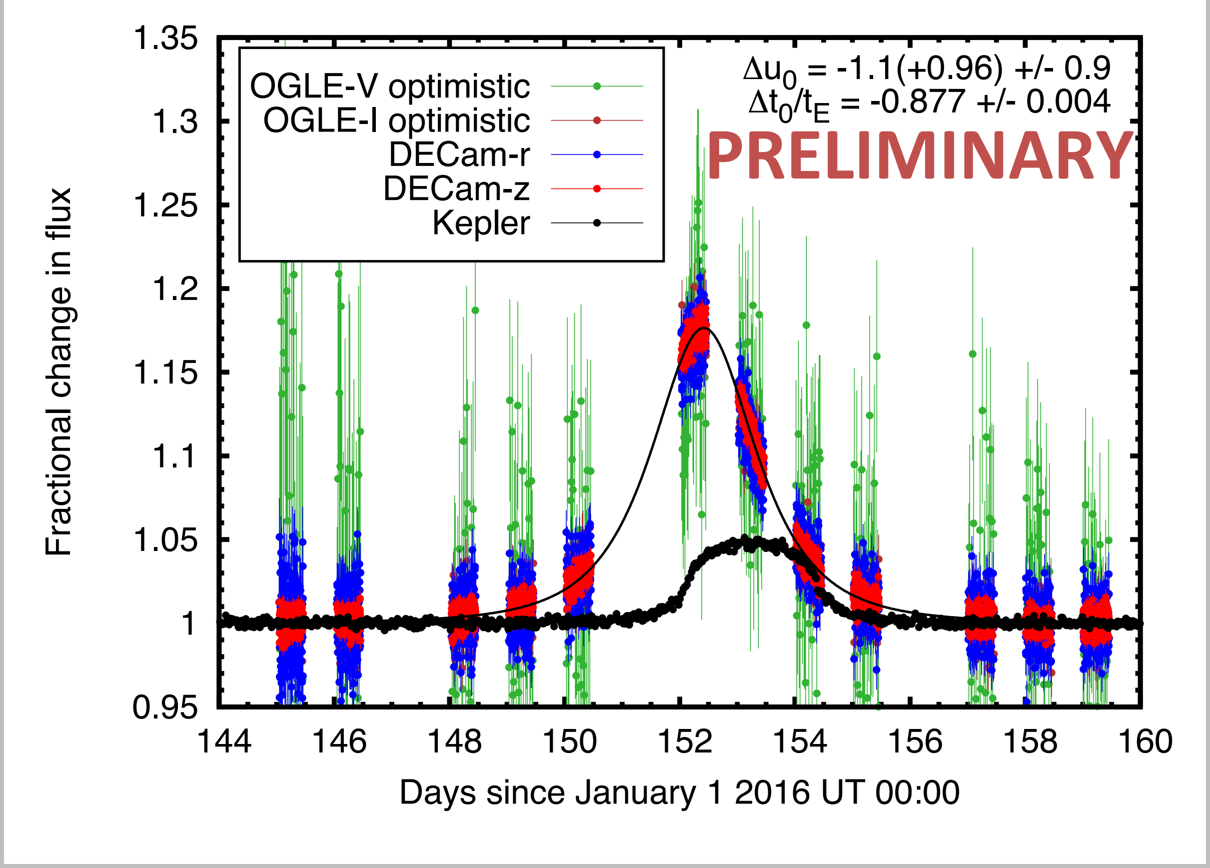
→ **Yield θ_E**



DECam FoV Credit: DES Collaboration

Free-floating Planet Masses
K2 + DECam

Example light curve (Saturn mass)



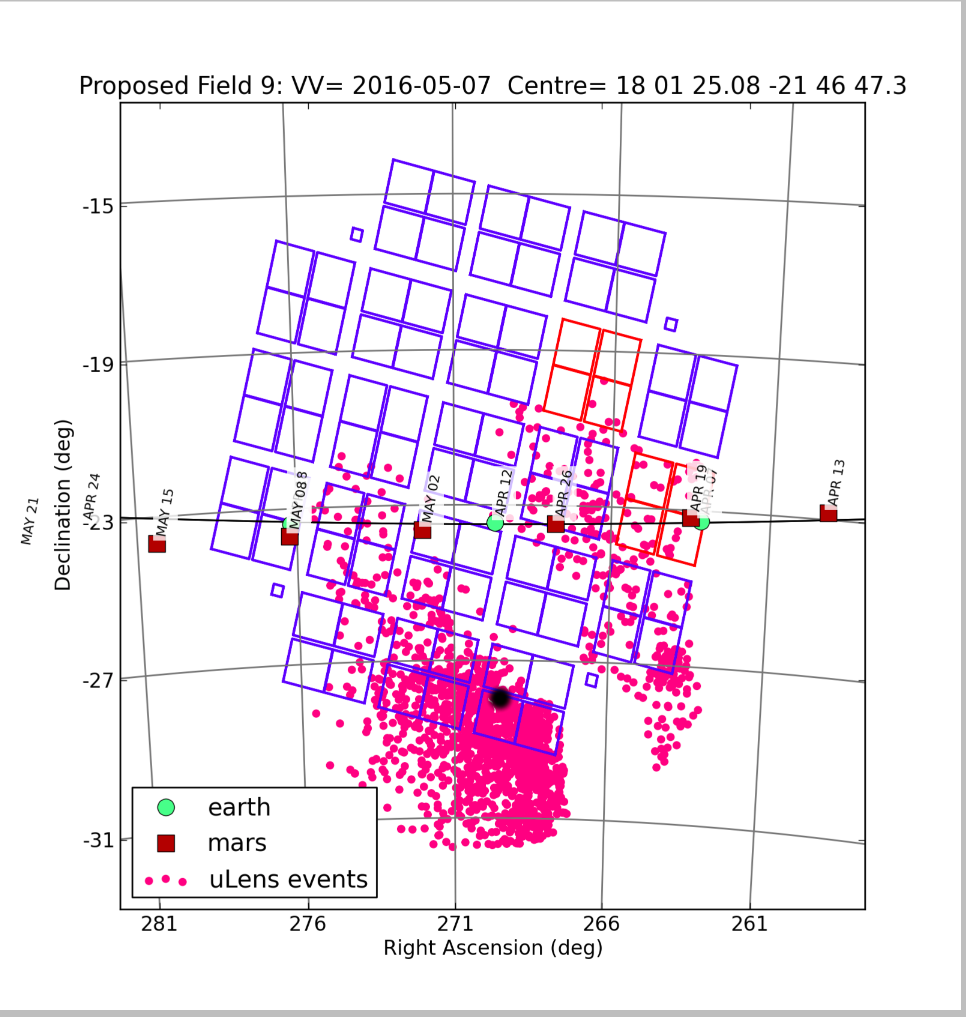
Credit: Matthew Penny, Sagan Fellow, Ohio State

Free-floating Planet Masses

K2 + DECam

PRELIMINARY!

M_p [M_{Earth}]	Number/ deg^2
10	0.03
100 (~Saturn)	**0.63**
316 (~Jupiter)	1.6
1000 (~3*Jupiter)	4.4



Credit: Matthew Penny, Sagan Fellow, Ohio State

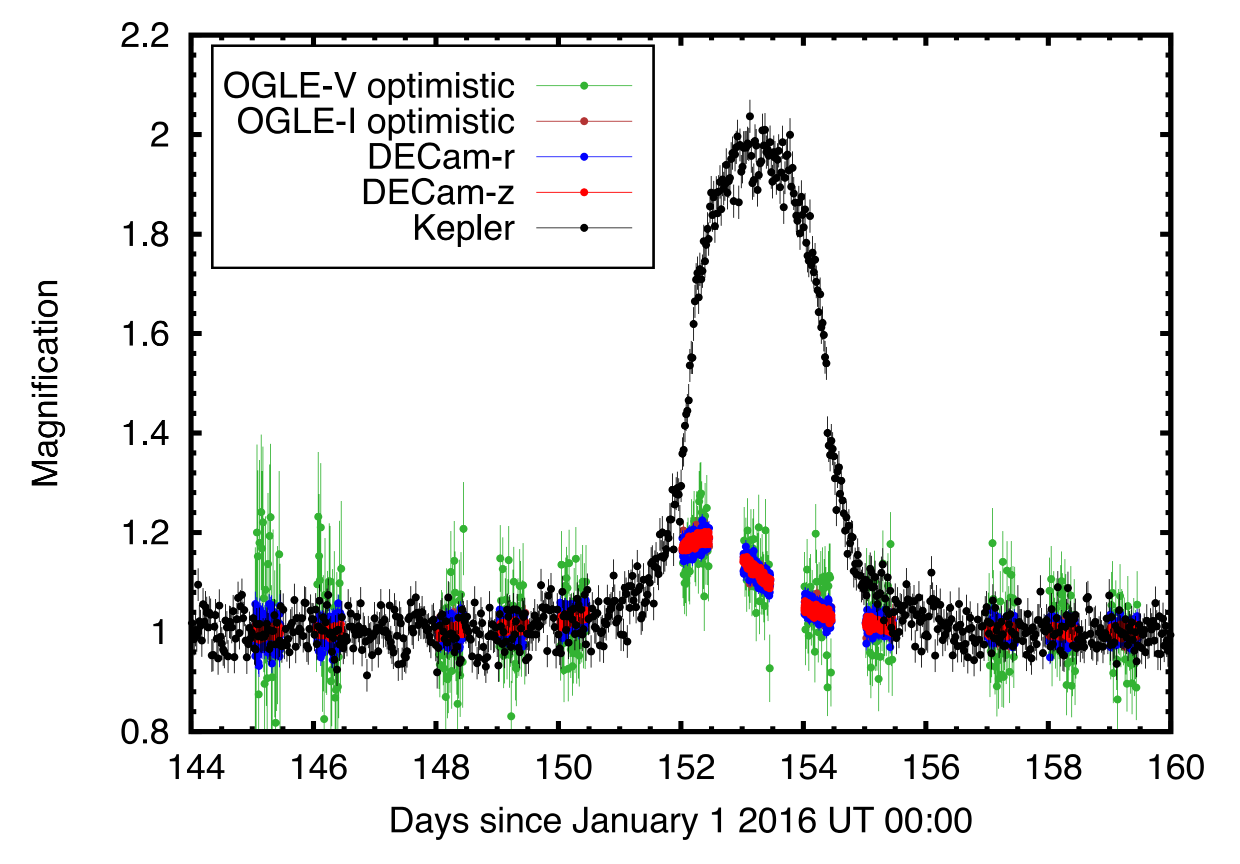
Summary

- Measure lens masses via microlens (satellite) parallax π_E
- **Has been done with Spitzer in 2014!**
- Possible via K2 Campaign 9 + DECam survey
- Great chance for **masses of FFPs**
- Can also get distances of lensing systems

Additional Slides

Free-floating Planet Masses
K2 + DECam

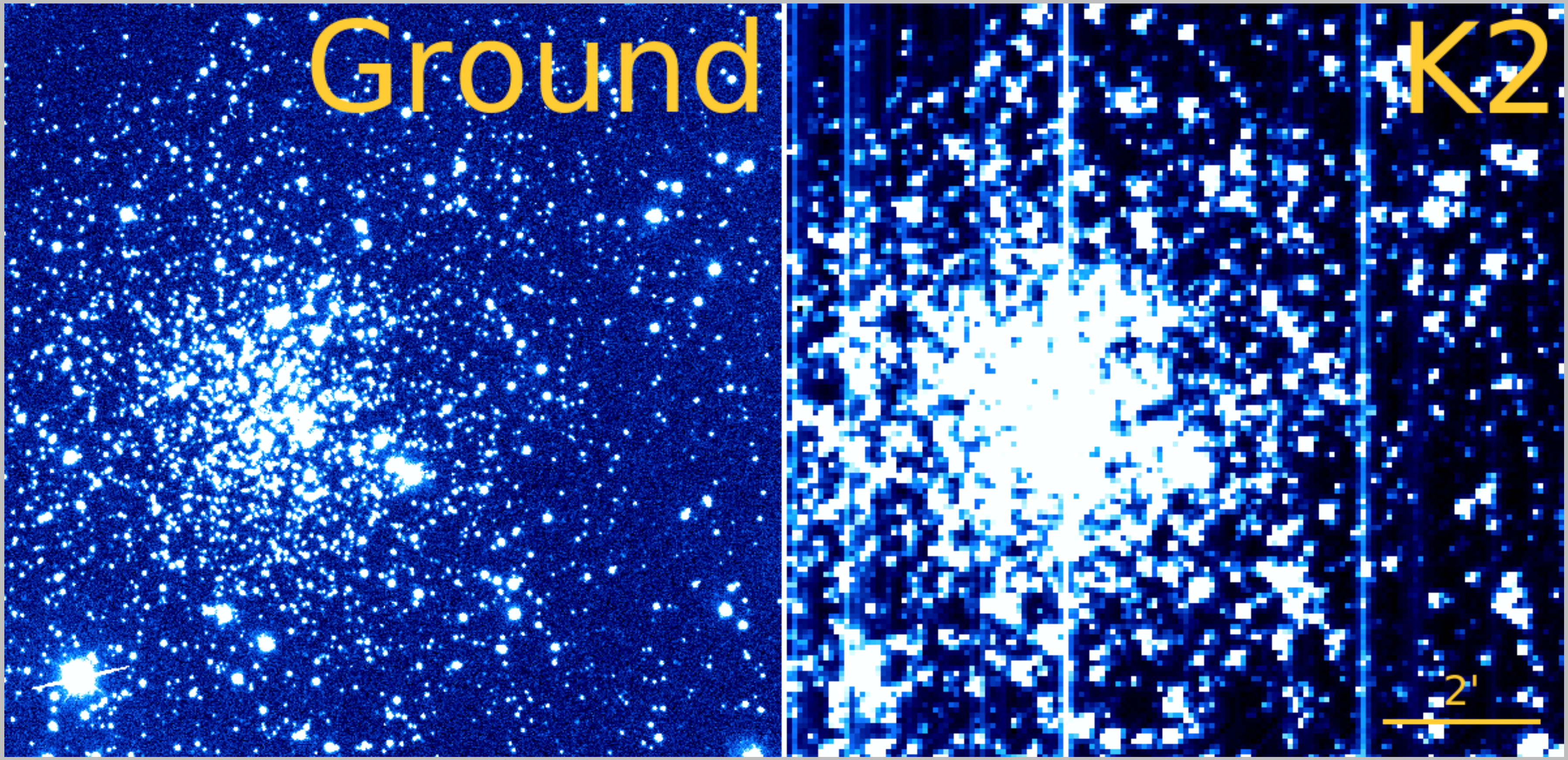
Example light curve (Saturn mass)



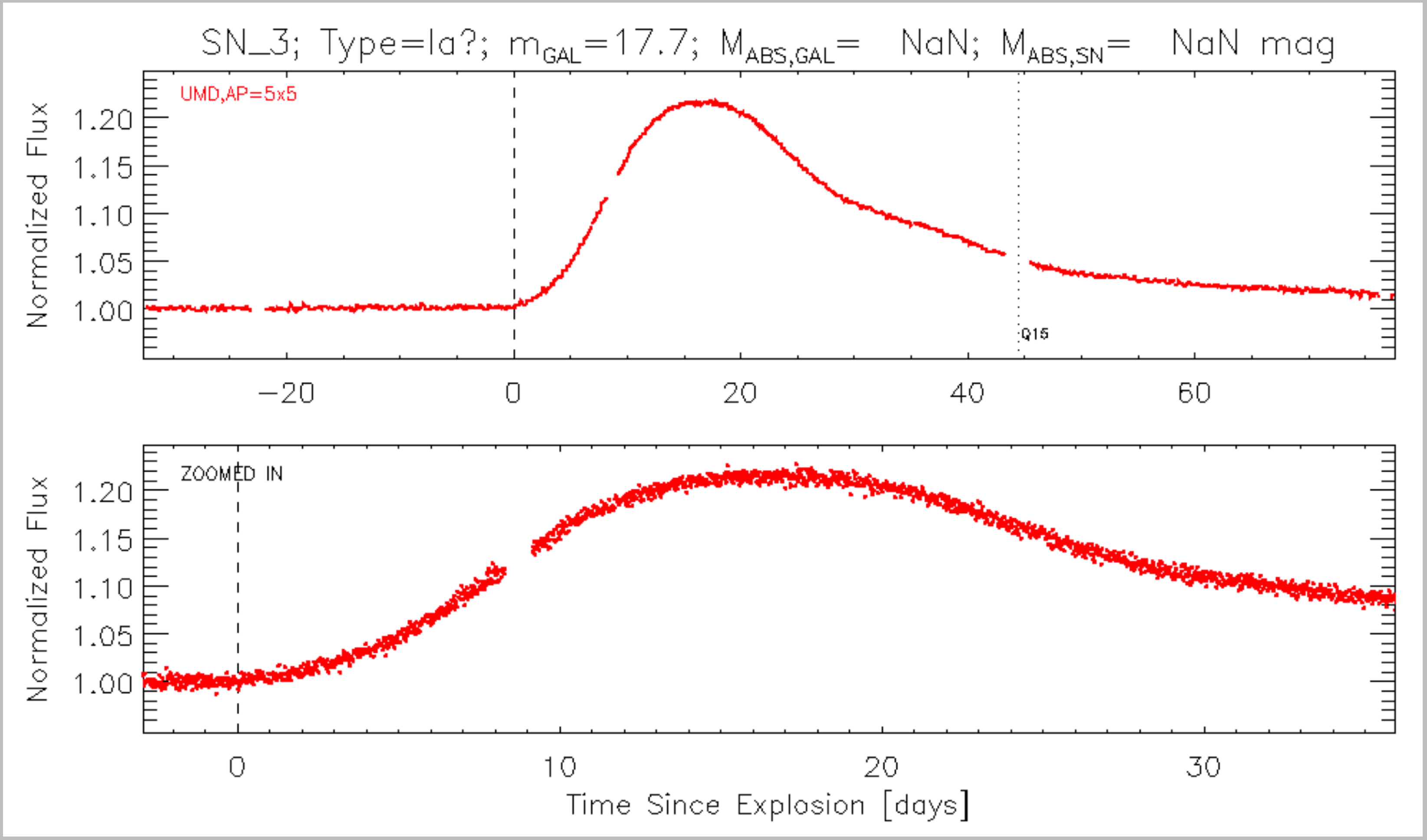
Credit: Matthew Penny, Sagan Fellow, Ohio State

K2 Blending

NGC 2158: Open cluster (Gemini)



K2 Magnitude Limit



Olling+ Kepler alternate science white paper

DECam vs. KMTNet

Pros

- Longitudinal coverage
  → CTIO, SAAO, SSO
- Comparable FoV
  → 4 sq. deg.

Cons

- Smaller aperture
  → 1.6m
- No first light yet?
- Automated survey
- Data proprietary?

DECam vs. OGLE-IV

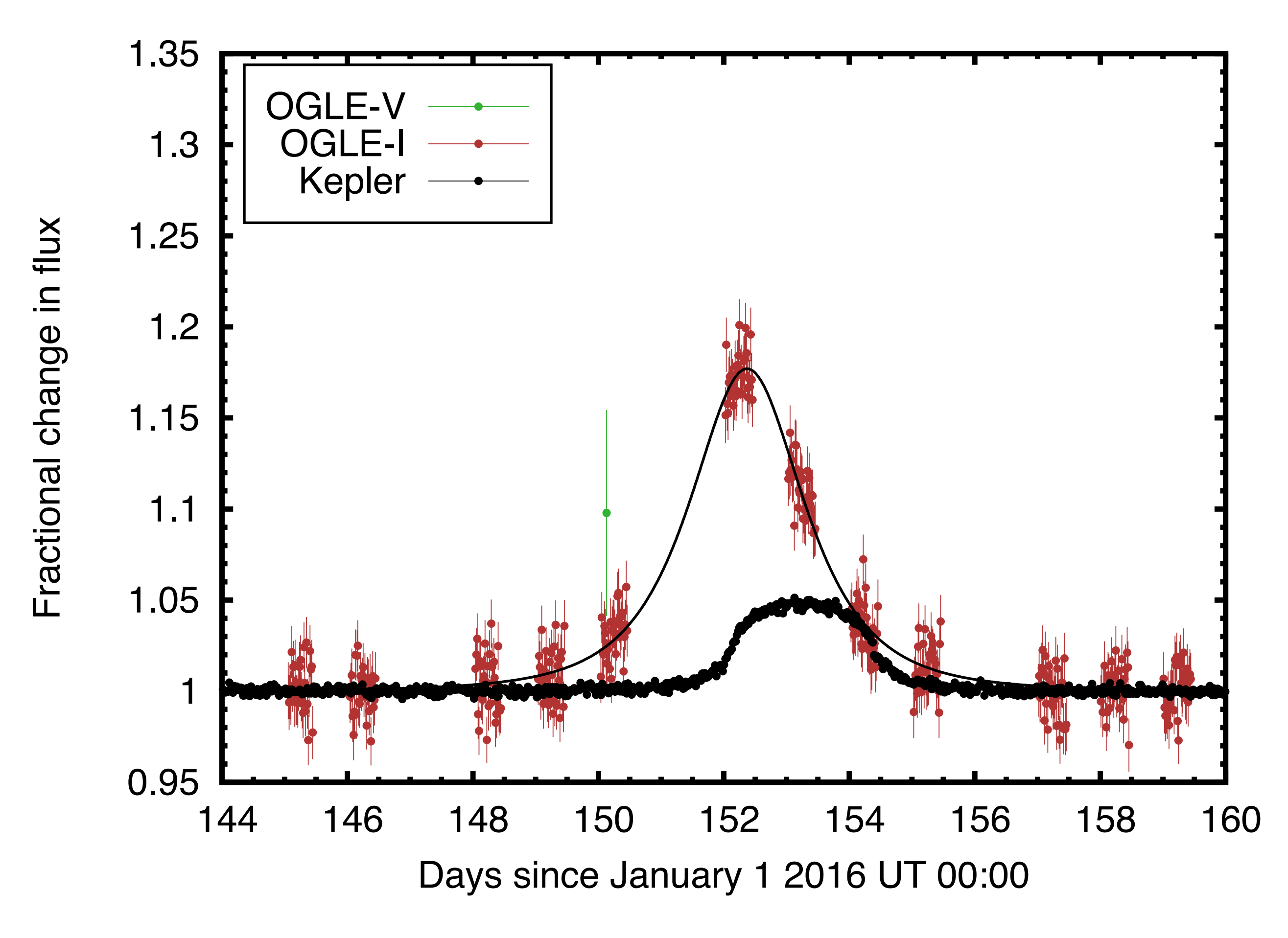
Pros

- Exists and operational!

Cons

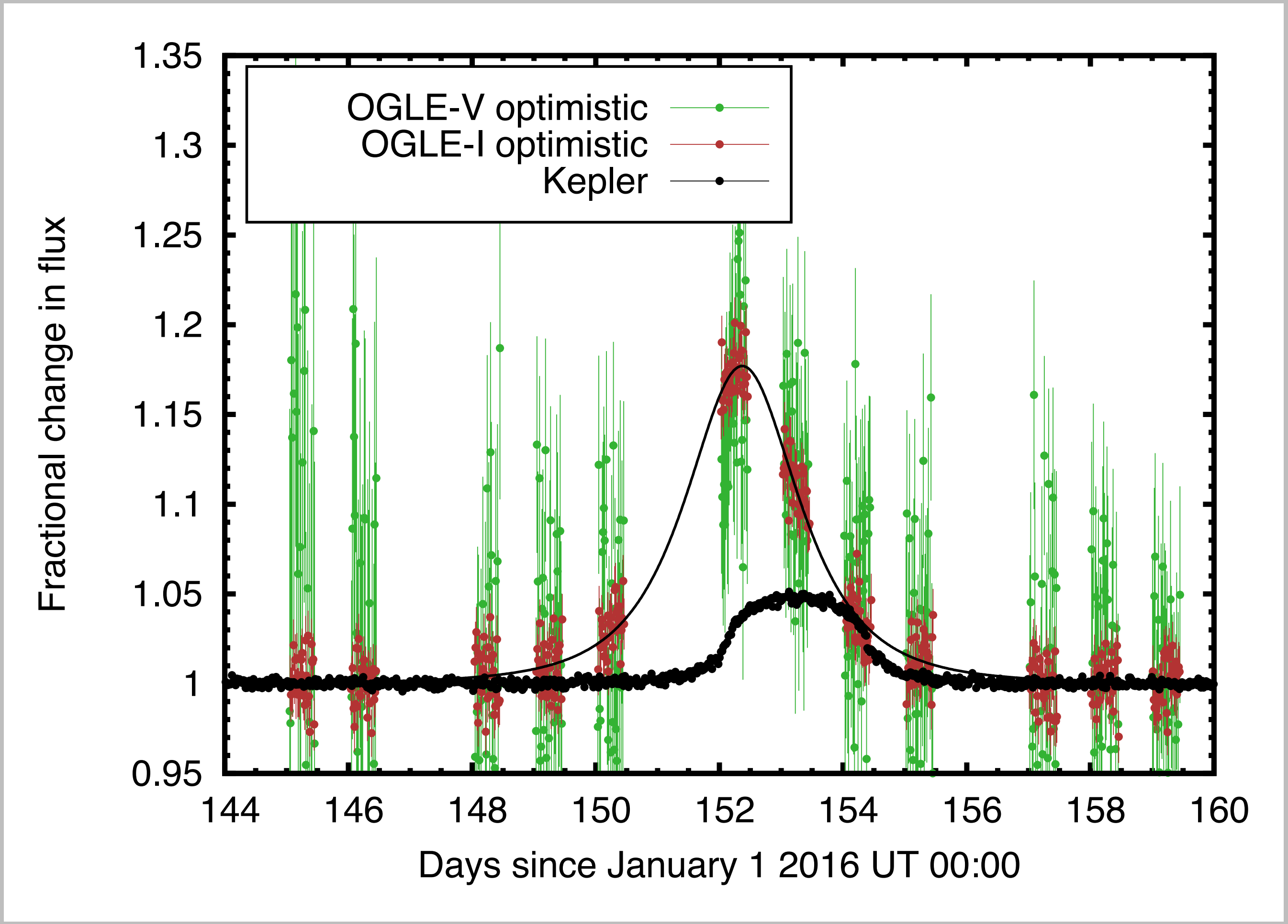
- Smaller aperture
  → 1.3m
- Worse color cadence
  → 1/(~20 days)
- Smaller FoV
  → 1.4 sq. deg.

DECam vs. OGLE-IV



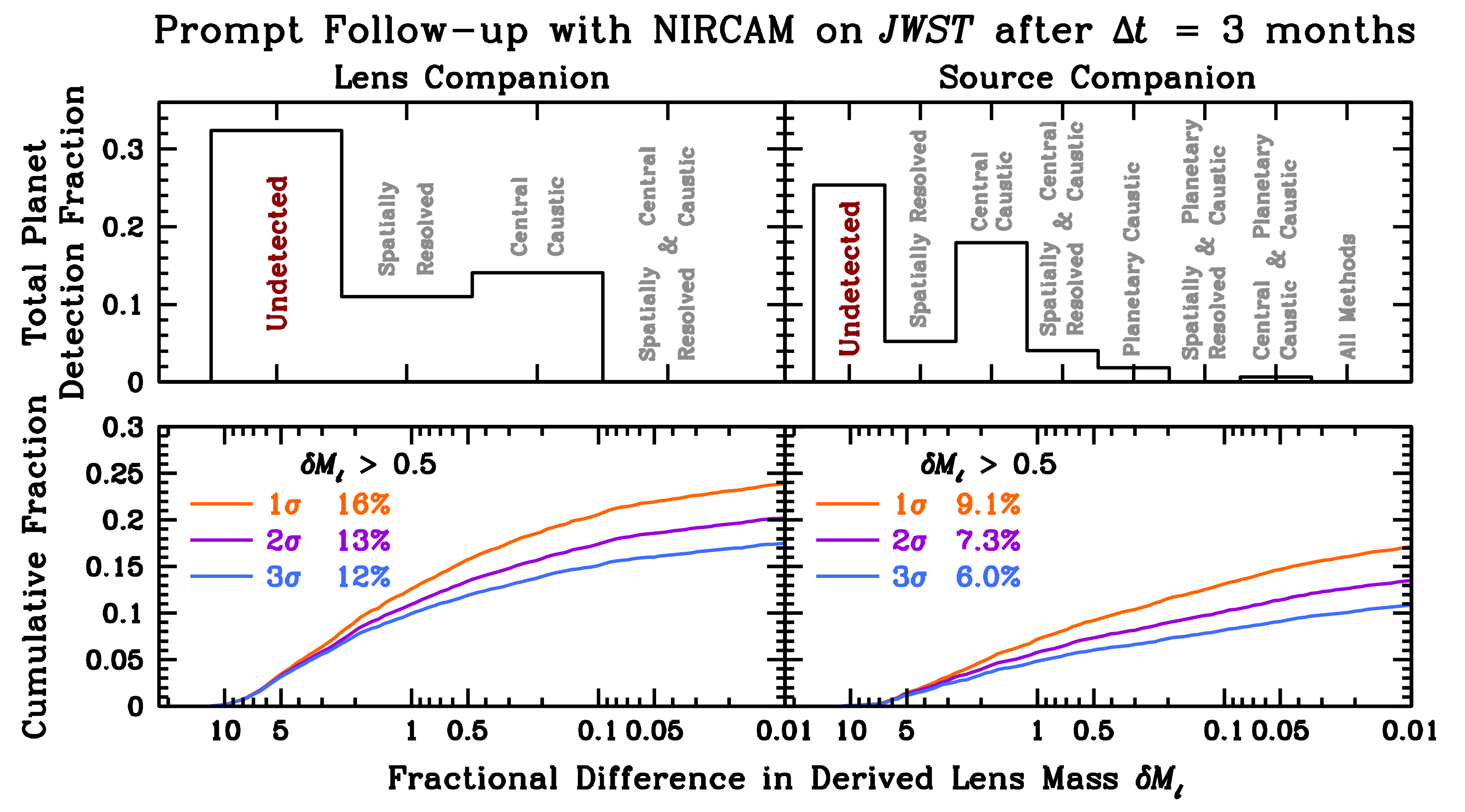
Credit: Matthew Penny, Sagan Fellow, Ohio State

DECam vs. OGLE-IV



Credit: Matthew Penny, Sagan Fellow, Ohio State

Lens Flux Contamination



Henderson (2014), arXiv: 1410.4843